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NAVAL POLICIES AND DEVELOPMENT SINCE THE WORLD WAR.*

BY

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I feel highly honored that I have been requested to address such a distinguished audience.

When the invitation was first tendered, I knew little of The Franklin Institute and its work. When, upon investigation, I learned of the great work the Institute has accomplished in scientific research and in dissemination of knowledge to the public, frankly, I was worried. And when, in reviewing some of the numerous activities of the Institute, I learned that among your lecturers in the past have been some of the most eminent scientists, inventors and engineers, of this and previous generations—well, to put it mildly, a cold chill crept down my spine and settled in my feet. I knew that I was not a scientist, engineer or inventor. Could it possibly have been my close association with the magic name of Edison that had drawn me into my present difficulty?

The title selected is so broad that I feel my discussion should be limited to a few of its most important phases. For that reason, I will stress principally the RESEARCH AND DEVELOPMENT PROGRAM which has contributed so much to our Navy's present state of high efficiency.

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* Presented at the Stated Meeting held Wednesday October 16, 1940.

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

Before proceeding, let me quote briefly the Naval Research Policy, "to promote, by continuous research and investigation, the application of scientific discoveries and technical invention to the improvement of Naval Material."

In my discussion I will attempt to point out the effect of this policy on the Navy's development since the last war.

When the armistice was signed in 1918 this country had a strong, efficient Navy, second only to that of Great Britain. We were then engaged in a building program, initiated in 1916, which if carried to completion would have given us the strongest Navy in the world. But the American people, and the people of most other great nations, were sick of war and were burdened with excessive taxation. In an effort to reduce all unnecessary expenditures, one of the first items viewed with alarm was the rising cost of Naval programs.

In 1922 the Disarmament Conference was called and the five leading World Naval Powers agreed to cease competitive building and to limit their Naval strength to a definite tonnage ratio. I shall not take up your time with the statistics. The net result was that our building program went by the board and only a few of the ships, which were over 90 per cent. completed, were finished. The remainder, with a number of over-age ships, were scrapped, and we came out of the conference with a Navy theoretically equal, but actually weaker than that of Great Britain,—although the tonnage ratio was 5 : 5 : 3 for the United States, Great Britain and Japan, as specified in the treaty.

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One of the features of this treaty was a 10-year battleship holiday and a limitation in tonnage of all other combatant types.

An agreement of this nature might have proved successful provided the treaty had been respected. But the United States was swept with a wave of disarmament. Since we were separated from our potential enemies by a broad ocean on each side, Congress, at the insistence of the people, decided to try disarmament by example. The theory was that since we were best able financially to build a large Navy, we should set an example and slow down building, expecting that the other nations would naturally follow our lead. In this, however, we were sadly mistaken. The other powers kept their strength up to treaty limits while we dropped below Great Britain's quota and approached that of Japan.

Before proceeding, I should like to pause for a few remarks on the disarmament conference. A statement of one of the parties to this conference probably is an accurate expression of the thought on which the success of such a conference was predicated. I quote:

> "As between the great stable powers, the sanctity of treaty agreements is held to rigidly, and only a convulsion should cause the breaking of such arrangements, since preceding war there is always the method of the meeting of the minds of the powers concerned to change any arrangement thought unsatisfactory."

This conception even ignores the facts surrounding the declarations of war in 1914. There was no first meeting of the minds of the powers to discuss arrangements then. There was a 48-hour ultimatum followed by a declaration of war, with an immediate invasion of a neutral state without any previous declaration. How far such wishful thinking is from the actualities of today needs no further exposition. In 1938, at Munich, we saw "a meeting of the minds," and then when the aggressor was ready, we saw one neutral after another invaded and conquered, without the barest formality of a declaration of war.

If the events of the past year have taught us nothing else, we have learned that these times do not permit either wishful thinking or appeasement.

It was during the period of this Naval building holiday that the airplane was being rapidly developed by the Army and Navy for military purposes, and by large commercial interests for the transportation of passengers, freight and mail. Transcontinental and transoceanic flights were undertaken, and the airplane gradually captured the headlines as the military weapon of the future. According to some authorities and many writers, it would eliminate the need for battleships and possibly of large Navies.

The discussion brought forth almost interminable controversy which most of you will recall. Most Naval authorities, particularly those of the United States and Great

Britain, were on the spot to justify the continuation of expensive building programs. This matter was given exhaustive consideration.

The Army and Navy reported that, in their opinion, air forces could not fully protect our industrial centers and cities from aircraft attack from beyond the seas, if an enemy had control of the seas. They further reported that shore-based aircraft could not take the place of a mobile fleet. This opinion was accepted by our Congress.

The British Committee of Imperial Defense in a later investigation and report on this subject expressed their opinion in a clear and forceful manner to this effect. I quote:

> "The advocates of the extreme air view would wish this country to build no capital ships (other powers still continuing to build them). If their theories turn out well founded, we have wasted money; if ill founded, we would, in putting them to the test, have lost the Empire."

In the light of recent events, with the invasion of the British Isles still not having proceeded beyond the conversational stage, how fortunate that the British Navy and British statesmen had the vision and courage to take this stand.

Our own Navy was equally emphatic in condemning a principle, which, if accepted, would have gambled with the lives of our citizens and with the very future of our nation.

Looking back on this controversy it is now perfectly clear that the argument against the battleship, which was voiced principally by a few ultra proponents of air power, was based principally on economic pressure, and not on lack of usefulness of the type.

In 1929 Congress finally recognized the fact that the other powers were promoting a building race in everything except battleships and that we were lagging far behind. Fifteen 10,000 ton cruisers and one aircraft carrier were therefore authorized, but this program was suspended the following year, pending the results of the London conference, held in 1930. By this treaty Japan obtained parity in submarine tonnage and a 70 per cent. ratio in heavy cruisers and destroyers. Actually, due to our over-age ships, Japan had then crept perilously close to equality in actual strength.

While the Navy building program was taking a holiday from 1922 to 1933, what was happening in the way of research and development, to improve the quality of our material? At the beginning of the first World War the Secretary of the Navy appointed a Naval Consulting Board of eminent scientists and inventors to assist the Navy in research, investigation and appraisal of inventions. The chairman of the Board was the great and beloved Thomas A. Edison. At the end of the War this Board made a monumental contribution to the Navy and the country when it recommended the establishment of a Naval Research Laboratory for fundamental physical and chemical research and investigation. This recommendation was approved by Congress and in 1923 the Naval Research Laboratory was established at Anacostia, D. C., across the river from the capitol.

While its funds and facilities were at first greatly restricted, it was here, during the lean years of Naval Construction, that the advances in science and engineering were carefully investigated, and the knowledge gained was used for the improvement of the material of the Fleet.

Other stations and laboratories contributed their share to this program, notably the Boiler Laboratory and the Naval Aircraft Factory situated here in Philadelphia. The Torpedo Station at Newport, the Naval Gun Factory and Ordnance Laboratory in Washington, and the Naval Experiment Station in Annapolis all contributed their share.

Unfortunately, however, this work was greatly limited by small appropriations due to our Naval economy program. But much research was done in the field of pure and applied science and in all branches of engineering, and this continued effort bore fruit in greatly improved material and equipment for the Fleet.

In 1933, due to the curtailment in building, and small Naval appropriations, the present administration found our Navy in urgent need of ships of all types, if our treaty strength was to be maintained.

Immediate steps were taken to correct this condition. This brought forth loud protests from Japan that we were starting a building race, but fortunately her protests were ignored.

President Roosevelt, by Executive Order, diverted $250,000,000 of National Industrial Recovery funds to commence a new building program, and thirty-two combatant ships were laid down. All of these were completed and have been with the Fleet for several years.

In 1934 The Vinson-Trammell Act was passed, authorizing a building program to regain our treaty strength.

We were far behind in Cruiser, Destroyer and Submarine strength, and steps were immediately taken to remedy this condition. Now we were to profit from the results of many years of Engineering Research. Foreign Navies had been building new Destroyers and Cruisers while we were idle. The speeds of the new Destroyers had been increased from 5 to 6 knots over the older ships of this type, but the cruising radius remained about the same. We needed a long cruising radius, due to our necessary operations in the Pacific. Therefore the ability to compete in speed required a radical departure in the Engineering plants. The Chief of the Bureau of Engineering, Rear Admiral Bowen, who is one of your honored guests this evening, decided to increase both the steam pressures and temperatures of the boilers and turbines, in order to obtain the necessary increase in power without an increase in weight and required machinery space. The latest developments in Metallurgy and manufacturing processes permitted this change with perfect safety, and the work was undertaken. This change met with strenuous objections from some sources, but the results obtained amply justified the decision. The first plant completed has now been in operation more than three years and the results have exceeded all expectations. As a result of this change all of our new turbine driven ships will have plants of this type, and we shall no longer have to concede a speed superiority to foreign navies, while we shall excel them in cruising radius and economy.

About this time the then Secretary of the Navy, the Honorable Charles Edison, decided that research and invention should be given more independence and prestige. He therefore transferred the Naval Research Laboratory and the Office of Inventions to the Secretary's Office, and placed Admiral Bowen at the head of these activities.

An Advisory Council for research was appointed with four of the country's leading civilian scientists and Admiral Bowen as members.

Contact was made with all leading Commercial and University Laboratories of this country, and a plan for complete exchange of information regarding research problems was instituted. Under this arrangement the inventions and discoveries of all these laboratories, if they pertain to national defense, are made available for use without delay or formality and at no cost to the Government.

Due to the outbreak of the present war, Congress, early in 1940 authorized an 11 per cent. increase in Naval strength. When the Low countries were attacked and over-run by Hitler, without warning or declaration of war, the futility of depending on anything but armed force for protection was forcefully demonstrated. The President called for an adequate Navy to meet this sudden peril and Congress passed the so-called "Two Ocean Navy Bill," authorizing an increase of 70 per cent. over the tonnage then built and building, and increasing the number of Naval Aircraft to 15,000.

The results of many years of research and planning now paid big dividends. The Navy General Board and the Navy's Technical Bureaus had been preparing for such an eventuality for many years, and had decided on the numbers, sizes and types of ships required for a two-ocean Navy.

The Technical Bureaus had drawn up complete plans and specifications for these ships and all their necessary equipment, and had kept these plans up to date from the results of the research program. Shipbuilders and manufacturers had been contacted long in advance, and their facilities and needs for such a program had been carefully investigated. When the legislation to authorize and finance this 70 per cent. increase was first introduced in Congress, the Navy Department immediately contacted these shipbuilders and manufacturers, and tentative negotiations were instituted to cover this program.

The net result of this planning was that contracts for practically all of the authorized tonnage, amounting in cost to about four billion dollars, were either in the mail or on the wire two hours after the President signed the Bill. This accomplishment dwarfs any similar previous undertaking of this, or any other nation, and should for once still the cries of the critics, who so frequently accuse our Navy of being overburdened with red tape and bureaucracy.

What is now being done to increase our Naval strength and meet the challenge of ruthless aggression is well known to all of you. Ships and planes are being rushed to completion as fast as all the facilities of the nation can be mobilized. Many new Air and Naval Bases, both on this Continent and on numerous Islands in the Atlantic, Pacific and Caribbean, are being built and fortified. When this program is completed, this country, and the whole Western Hemisphere, should be able to stand impregnable against an attack from any possible combination of enemies.

America at last has awakened to the full realization of her danger. With her will for peace, and her hate for war—unwilling—she has been goaded to action. In all her splendor, she now stands ready to the challenge.

MAN'S BATTLE AGAINST FIRE.*

BY

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The important part which fire has played in the development of civilized life needs no emphasis. The first use of fire by our remote ancestor, the ape-like man, was one of the influences which made a man of him. The transformation of the heat of combustion into mechanical work—the result of fifty centuries of human effort—gave us the Mechanical Revolution. The application of modern knowledge of heat has enabled us to overcome, to some extent at least, nature's alternation of night and day, and the discomforts of seasonal change.

But it is not of man's discovery of fire that I desire to speak tonight, nor of his control of fire for useful ends. Not of fire as the servant of man, but rather of man's struggle to keep mastery over the processes of combustion. For fire is neutral and unmoral, it may build or it may destroy, and when it goes on a rampage, when it seeks to become master rather than servant, the hard won accomplishments of the years may pass up in a few moments of smoke.

Man has long faced, as we still do today, the dangers of forest and grass fires but, ever since man began to live in habitations, he has faced hazards of fire of his own making. I recall with interest a note in Winthrop's journal—a record of the pioneer settlement of New England—where he records that in September, 1630, "Finch of Watertown has his wigwam burnt and all his goods." This loss was suffered by an ancestor of mine who thus lost one of the earliest structures—an Englishman's wigwam, or rough pre-log house—built on American soil.

As community life developed and man began to build next to man, the building hazard increased. From Egyptian, Greek and Roman to Goth, Vandal and modern Robot, man has witnessed the destruction not only of individual homes but of whole cities by fire. Ancient Rome, the London of Samuel Pepys, the New York of Colonial Days, and the San Francisco of our own era, have trembled before the curse of fire let loose. Man has long been both using and fighting fire.

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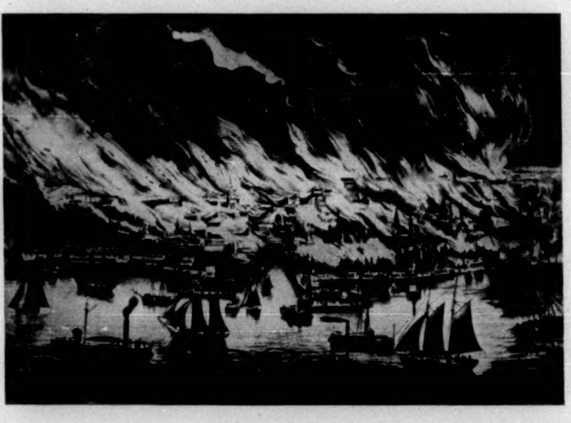
* Presented at the Stated Meeting, held Wednesday, December 20, 1939.

Hero of Alexandria, about the beginning of the Christian Era, was the first to describe a double cylinder hand-operated force pump which was, for some 19 centuries, the standard form of fire engine. In the third century Pliny, writing to Trajan from Asia Minor where he had been sent by the great Roman emperor to reform a corrupt government, reports that the city of Nicomedia had neither an engine nor buckets to extinguish fires, that he had organized a fire company of 150 members who hoped the emperor would supply presumably a Hero-type fire engine. In 1728 your own Benjamin Franklin, through his Junto, brought into being the first fire company in the United States and records with pride that, in his later

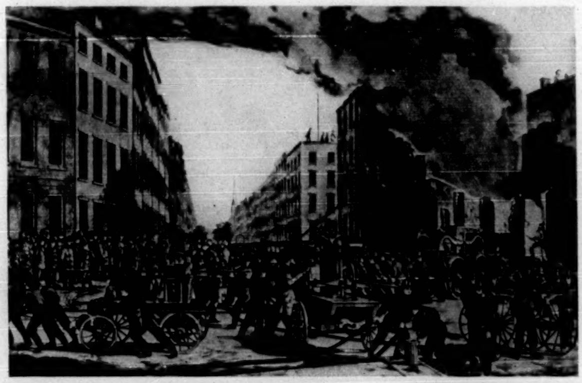
THE CHICAGO FIRE OF 1871.



Many of our American cities were swept by similar, destructive fires in the days when uncontrolled, flimsy frame construction permitted any owner to create fire hazards "ad lib." Modern building codes and the fire zone laws have reduced this danger in congested urban areas. From a contemporary lithograph.

life, Philadelphia "seldom lost more than one or two houses at a time."[1] It was Hero's pump that our grandfathers pulled along in those good old days that Currier and Ives pictured in "The Life of a Fireman." The volunteer fire companies of this country are still doing a fine piece of work in many of our smaller communities—demonstrating man's ability to coöperate in the field of liberty even in an age of government domination. Out of a total of about 14,000 fire-fighting services in the U. S. today, 13,000 are volunteer companies. While, in our larger cities, remarkably efficient public servants no longer drag the fire engine, no longer rely on the gallant, galloping horses of our youth, but go to fires on rolling internal combustion engines—and through traffic jams that look impossible to penetrate.

THE HAND PUMP FIRE ENGINE.



First described by Hero of Alexandria, used in Roman cities, and standard equipment until the second half of the 19th Century. Highly decorated pumps of this type were the pride of the Volunteer fire companies. A Currier lithograph.

Now all these efforts were and are directed at controlling and putting out fires whereas, if you look at the record, as Al Smith says, you will find that our comparative freedom in modern days from great city burnings, opera house holocausts, and hotel, apartment, tenement house, and similar horrors, is due, primarily, to fire prevention—not to fire fighting.

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[1] See Autobiography, p. 142.

Apparently Franklin, in addition to ways and means of quenching fires and removing persons and goods to places of safety, was also interested in the problem of preventing the starting of fires through accident or carelessness and in developing fire-resistant construction.[2] Since Franklin's day, the engineer has replaced the candle and oil lamp with electric light, the open fire with steam or water heating, and a great hazard has thus been removed. The law also has stepped in to help in this direction by regulating the storage of inflammable liquids or other materials, and by setting up in many of our cities "fire limits" which bound areas of special hazard and value, and within which the construction of highly inflammable structures, such as frame buildings, is prohibited. And this brings me to the main topic which I want to discuss

THE HORSE-DRAWN STEAM ENGINE.

The use of this type of pumping engine paralleled the development of the municipal fire forces which succeeded the volunteer companies in our larger cities. One of the last horse-drawn engines was used in Dorchester, Mass., in 1925.

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[2] See letter to Samuel Rhoads, June 26, 1770.

this evening—fireproof construction. For it is the development of fire-resistive construction—the extended modern use of steel, cement, and other non-inflammable materials—which has been, together with the abandonment of the open flame for light and heat, an important contributing factor in reducing death and loss from fire.

MODERN MOTOR EQUIPMENT.

The gas engine has been adopted not only by city departments but has made possible a great increase in the effectiveness of the suburban and rural volunteer forces which still constitute over 90 per cent. of American fire departments. These could not readily maintain horses or keep up steam for immediate service and were thus forced to rely on obsolete equipment. Courtesy N. Y. Fire College.

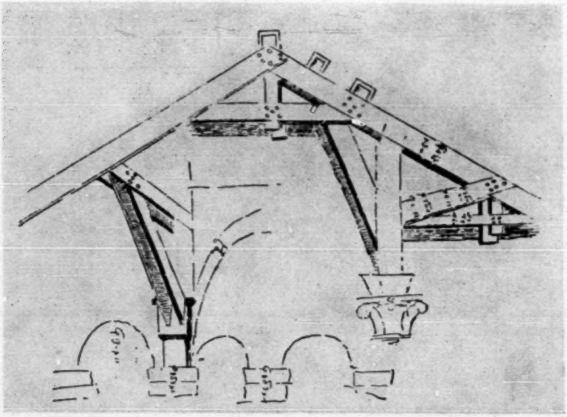
Strange as it may seem, the idea of fireproof construction—of building in materials which will not burn, and in such a way that the burning of contents—furnishings and goods—will not spread fire—is not a new one.

The Roman, for example, although he built many timber bridges, realized very clearly that a stone bridge not only was far more permanent from the standpoint of wind and weather, but that it could not be burned either behind or before him.

In fact, the Roman—first great stone bridge builder—was also a pioneer in fireproof building construction.

You may recall the huge dome, almost 150 ft. in diameter, of the Pantheon at Rome with the name of Agrippa engraved over its portico. All Columbia graduates recall its form, for our great Low Memorial—center of our University building plan—was modeled after it.

FIRE RESISTANT CONSTRUCTION.

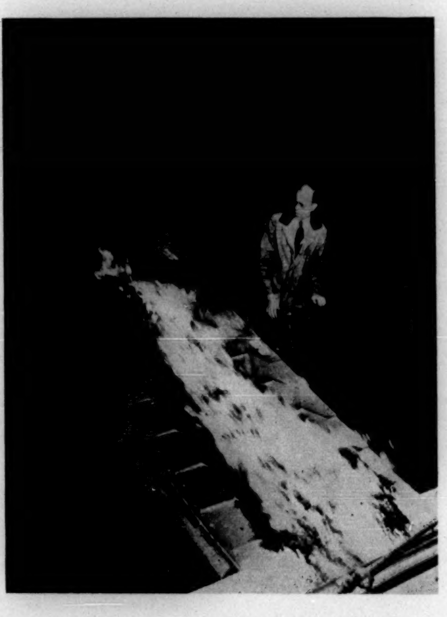


Even more important than fire-fighting equipment is the continuing battle to develop fire resistent construction. The Romans made a pioneer but ephemeral attempt in this direction in substituting bronze for wood in the portico of the Pantheon about 130 A.D.

Modern research attributes this work to the Emperor Hadrian about 130 A.D. instead of to Agrippa, right hand man of the first Roman emperor Augustus. In fact, this great structure—for over a thousand years the greatest dome in the world—replaced an earlier building which had been destroyed by fire resulting from lightning in 110 A.D., which, in turn, had replaced Agrippa's original building which was destroyed in the great fire of 80 A.D.

Hadrian took no chances. The walls of the Pantheon are brick and stone; its dome is a light, pumice concrete between curious so-called relieving arches of brick. Few people know, however, that the roof of the original portico was supported by the earliest metal truss known—a fireproof truss of bronze replaced the hitherto commonly-used timber roof.

TESTS OF A MODERN ROOFING.

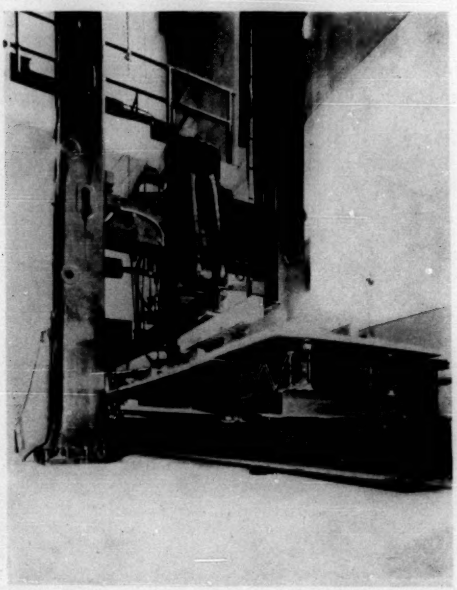


Modern construction is tested both for strength and for fire resistent qualities. Foremost among the laboratories conducting such "approval" tests is the Underwriters Laboratories in Chicago. Courtesy Underwriters Laboratories.

Unfortunately, in the later religious wars which Christianity encouraged, Pope Urban VIII had this truss pulled down and melted its 200 tons of brass into 80 bronze cannon. It was not until 1625 that this happened, however, and Renaissance artists have left us drawings which, at least, indicate the form of these first metal trusses. And note how closely this form forecast modern steel construction. Channels and plates and rivets just 18 centuries ago!

This was, of course, a remarkable but ephemeral development. An age of widespread fireproof construction had to wait upon the development of an age in which steel and cement were available in quantity and at a cost which makes fire-resistive construction practicable. The Bessemer converter and Siemens open hearth process for making steel and Aspden's discovery of Portland cement are epoch-marking developments not alone in metallurgy and engineering but for fire-

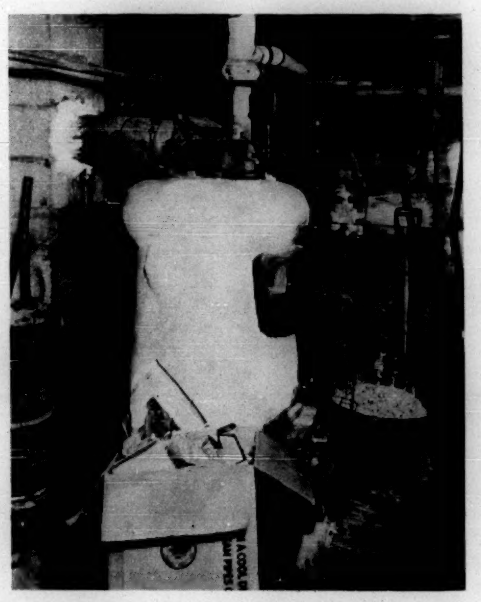
STRENGTH TESTS OF FLOOR CONSTRUCTION.



A modern "light floor" construction under test for safe load carrying capacity in the Research Laboratories of the Civil Engineering Department at Columbia University.

proof construction. In the modern fireproof building, the loads are supported by steel or reinforced concrete, the walls are of brick, block, cement or tile, the columns are "fireproofed" and the trim is of metal covered or fireproofed wood

THE CELLAR HAZARD.



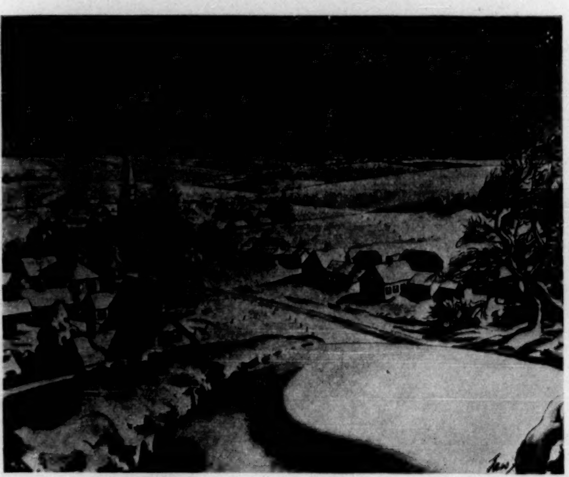
A third and most important line of defense in Man's Battle Against Fire is the reduction of dangerous and unnecessary fire hazards. The cellar of the frame building is usually an outstanding danger spot—it is no place to store odds and ends of inflammable materials. Courtesy Underwriters Laboratories.

and the only things which can burn are our clothes, for the furniture is probably metal and the hangings may also be fireproofed.

I use that word "fireproofed" advisedly for nothing is truly fireproof. All matter can be reduced to a molton condition by heat; even steel and concrete can be melted, and the best we can do with inflammable materials, such as wood or cloth, is to render them relatively non-inflammable by chemicals—so that they will not support combustion.

Some of you are undoubtedly wondering how this change has been brought about. A fireproof building is, of course, far more costly to build than lighter, frame, wood construction. Unfortunately the matter of saving and conserving human life is too often neglected in the stern struggle of economic competition. We would still have city burnings, opera house fires, etc., if it had not been for legislation on the one hand, continually mounting fire losses and insurance rates on the other.

THE DANGEROUS COUNTRYSIDE.



Courtesy, The Dow Chemical Company

Today one of the greatest dangers is in the country home—inflammable construction, poor provisions for exit, and inadequate water supply. This peaceful village is a series of potential bonfires. Modern construction would greatly reduce these hazards.

Legislation has forced safe construction—structurally safe and safe from avoidable fire hazards. The National Fire Protection Association has been an active force in education and in prodding city officials to take the necessary action to improve conditions and reduce fire hazards. City building laws, as we have noted, permit only the better classes of construction within congested and economically important areas. No one man or group of men can endanger the safety or gamble at the expense of the economic life of the community. Building Codes state in detailed and no uncertain terms the character, strength and other qualities essential for approved construction. New forms of construction must be tested before use and I show you now the tests of a new wall material which were made at our fire testing station at Columbia in order to secure the approval of our New York Building Department for a new building at the southwest corner of 56th Street and Fifth Avenue.*

I do not want to give the impression that all our city problems have been solved. San Francisco, our most destructive city conflagration, was destroyed in 1906, and there has been no great city burning since. On the other hand, there are smaller cities which are still in a dangerous condition—large areas of flimsy construction outside of fire limits. Chelsea, Mass. went up in 1907 to the tune of 12 million; Salem, Mass. followed in 1914; Paris, Texas, in 1916; Berkeley, California, in 1923; and in the last New England hurricane, New London, Conn., lost a million by fire. There is still work to be done in some of our cities. Furthermore, new materials also bring new hazards. The situation which made possible the Triangle Shirt Waist sweatshop fire of 1911 with its loss of 141 lives may have been corrected but we still recall the Crile Clinic in Cleveland where the burning of films stored in the cellar ended in the loss of 125 lives, and the horrible explosion and fire of the school in our southwest oil area, heated by natural gas, happened only two years ago. Eternal vigilance is the price of safety.

Outside our cities, building code and similar restrictions do not, of course, hold. Labor laws do require reasonable precautions in factory buildings wherever located. Houses are more or less isolated and if you choose to run the risk of fire, the burden is your own. The country village of frame construction and shingle roofs is simply a group of dormant bonfires. Nevertheless, wood has become more costly and both new materials which will not burn and fire-retardant forms of construction are coming into wider use. Modern industry has brought fire-resistive materials within reach of even the home builder's pocketbook. If you visited the World's Fair at New York and saw the Town of Tomorrow, you saw, through glass plates in the floor the use of small, light steel beams with cement, fiber board, asbestos products, and other forms of fire-resistant construction. The country home of today may be in quite a large measure fire-resistive—many modern forms of wall covering, of insulation, or even acoustic materials, have worth-while fire-stop values in retarding the spread of fire in its earliest stages—those most important "first five minutes." On the other hand, a country house may be a beautiful fire-trap awaiting only the touch of a match to put it off. The sensible home builder takes advantage of the modern fire-repellent, relatively inexpensive materials and methods of construction which have been developed by modern technology and industry.

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* At this point in the lecture a brief motion picture film was shown.

But the use of fire-resistive materials is but part of the story. Over half of all fires in buildings have their origin in cellars or basements. There we usually find heating equipment, there also are storage rooms with discarded furnishings, bits of wood saved up "to start a fire" and, in other cases, paint and carpenter shops and other dangerous services. Clearly a fire-resistive first floor is a fire-stop against the spread of over fifty per cent. of our fires, but carelessness is a vital factor. One home in the United States is burned every minute and a half, a death from fire occurs every 50 minutes. The largest single cause is carelessness on the part of smokers or those who handle matches—27 per cent. of fires start this way. I always liked the slogan produced by a school-boy competition: "A match has a head but no brains. When you use its head, use your brains."

To return to the basement where half our fires start—from the basement or cellar, stairwells, elevator shafts, air ducts, and similar constructions often provide a ready means of spreading a basement fire to upper stories. Fire-stops in the form of partitions with metal covered self-closing doors are essential.

Also, with each new type of house service, new hazards must be met. The recent vogue in air-conditioning led to the construction of air ducts which, intended to convey only cooled or warmed air, were frequently lined with semi-combustible material. They were found to provide an excellent system of arteries to spread fire to every room in a building and were so constructed and located that only a Mickey Mouse fire brigade could possibly get water inside the burning conduits.

Then there is the matter of enforcing the standards necessary to afford proper protection in the electric and heating services themselves. Fuses to prevent overloading of line. Only a never-ceasing vigilance protects the unwary customer, or the man who wants "the cheapest," from flimsy electric fixtures and switches, and from sub-standard fixture cords or connectors. Watch your cords on your older floor and table lamps, hot pads, and other portable equipment, for even the best wear out in time, and a short circuit may mean a bad burn or a fire.

Even all these precautions and reprisals have still left us with an average fire loss during the last ten years of nearly half a billion dollars annually, and the average annual loss of life in the same period is estimated at over ten thousand. Law or construction, fire departments or alarm systems, cannot alone solve this remaining problem for sixty per cent. of those lost today are the victims of home tragedies. Every home owner has a moral obligation to be intelligent.

Finally, no survey, however brief, of the problem of controlling fire would be complete without a word on the work of the National Board of Fire Underwriters. Back in 1866, some 150 fire insurance companies joined together to support a national organization. In its earlier days, this organization was probably just another organization, just another example of the great American craze for organizing. At that time the fire insurance business was pretty much a gamble, as far as risks were concerned, and a cut-throat game in the battle of premiums. Undoubtedly these companies came together in the first instance to eliminate unfair competition and to fix reasonable rates. It was not long, however, before it became clear that agreement on reasonable rates would not alone save the companies from the great gambles of the business. Major risks could be divided between several companies but a great city burning has put more than one company out of business.

Now the modern fire insurance company is not in business on a temporary basis—it is no fly-by-night concern ready to take a great gamble in the chance of making a great profit and then skipping on to "skim-the-cream" as the saying goes, in some other field. It is in the insurance business—was yesterday, is today, and will be tomorrow.

Clearly, therefore, if the gamble in this business can be reduced, if major risks can be eliminated, and if rates can be proportioned to risks, the insurance business would take on a stability and soundness which it would otherwise sadly lack. The Board, therefore, deliberately set about encouraging the development of fire-resistive materials and construction, and educating the public to the advantages of efficient fire protection and proper design.

Today the National Board of Fire Underwriters has established in Chicago a great laboratory for testing all kinds of construction materials, electrical and other equipment, fixtures and appliances. Perhaps you recall an article in the *Reader's Digest*—which seems, by the way, to have replaced "Poor Richard" in the American home. It was called "Foolproofing America." The next time you buy a few feet of wire for your "bridge lamp," note the little metal band that encircles the wire. "Passed by the Underwriters' Laboratories" is assurance that what you buy is up to reasonable modern standards. The "U. L." is now a separate, self-supporting agency, and some half-billion of its labels a year are attached to approved products. The Board has thus probably done more to raise the standards of fire-resistant construction and to encourage the development of new and better materials and construction than any other single agency in our country.

Insurance companies also set base rates for fire insurance in many cities only after the Board has made a careful survey of fire hazards in that city. Field parties from the Board have examined the water supplies, fire departments and equipment, the building laws, and the relationship of hazardous construction to prevailing winds, etc., of about 500 cities throughout the United States. The chances are that if you live in a city of 25,000 inhabitants, the Board has published a report on your fire risks and facilities which leaves nothing to the imagination and offers no balm for injured feelings. It does not set rates but it surveys and reports on the basic factors which determine rates.

Now I have attributed all this splendid work, not to a humanitarian motive on the part of the Board directed at saving life and property but to a desire to improve and stabilize the fire insurance business. I may be wrong. I am not working for nor have I ever had any connections with the National Board of Fire Underwriters. I would be blind, however, if I did not point out the far reaching effects of its activities and the remarkable public service which the Board has rendered in its over seventy years of service.

For example:

If your city has effective building laws, prohibits inflammable construction in congested areas, enforces a reasonable code of building construction, maintains an up-to-date and efficient fire department, an adequate and reliable water supply, and an effective pipe system for distributing this water—you get the benefit of low premiums on your fire insurance.

If your laws are inadequate and poorly enforced, your fire equipment obsolete and your water mains inadequate to furnish water in sufficient quantity and pressure at points of fire hazard—you pay the bill for negligence in increased rates and your city fathers know it. The Board even makes recommendations in its reports and shows how you can improve your water supply by new connecting mains, etc.!

In this way the National Board of Fire Underwriters exerts its powerful influence to reduce fire risks and advance fireproof construction. In this work they coöperate with the N. F. P. A. which not only is a crusading and educational organization but is working on specifications and standards. A few private agencies also help. Columbia has done her part in this great work—our Professor Woolson became Chief

Engineer for the Underwriters and our staff is active in testing and committee work. Thus, in developing a long-range policy which seeks to stabilize its business and insure a continuity of operation in the interest of its clients and its owners, the Fire Underwriters, and these other agencies, are performing a more general social service that leads to safer living and higher standards of life for all the people. They are leaders in man's struggle for mastery over fire.

THE ELIMINATION OF HYPO FROM PHOTOGRAPHIC IMAGES.*

BY

J. I. CRABTREE, G. T. EATON, AND L. E. MUEHLER.

SUMMARY.

It is very difficult, if not impossible, to remove the last traces of hypo from photographic papers by any known procedure of washing. The sulfur in the residual hypo ultimately, and especially under abnormal conditions of temperature and humidity, combines with the silver image to form yellowish brown silver sulfide. This phenomenon is known as sulfiding or "fading" of the image. The various factors which affect the rate of fading of images and the washing out of hypo from films and papers are outlined.

Chemical methods of hypo elimination have been proposed from time to time but the majority of these have not been satisfactory because they tend to leave substances such as thionates in the photographic material, which are equally as difficult to wash out as hypo and which also tend to sulfide or fade the silver image. A new hypo eliminator is recommended consisting of two volatile chemicals, hydrogen peroxide and ammonia. This eliminator oxidizes the hypo to sodium sulfate, which is inert and soluble in water, while any excess eliminator evaporates on drying.

Two formulas and treatments are proposed: (1) Complete elimination of hypo for use by the professional, advanced amateur, and photofinisher who demand the highest standard of photographic quality in their prints. (2) Almost complete elimination of hypo (less than 0.01 milligram per square inch). Since the conditions to which prints will be subjected are rarely known in advance, use of the "complete elimination treatment" is advised in all cases.

In the processing of photographic developing-out materials such as gelatin silver emulsions coated on paper, film, or glass supports, if after fixation, the hypo (sodium or ammonium thiosulfate) is not completely eliminated from the processed material by washing or other means, under suitable conditions of temperature and humidity during storage the silver image will tend to "fade."

This fading is a result of the conversion of more or less of the silver image to silver sulfide by the sulfur present in the residual hypo, and is manifest by a change in hue of the image first to yellowish brown, then to yellow and, in most cases, the change is accompanied by a yellowing of the unexposed portions of the image. This yellowing of the highlights is a result either of (*a*) the use of an exhausted fixing bath, or (*b*) insufficient fixation whereby complex silver-sodium thiosulfates are retained and, under the proper conditions, decompose to give yellow silver sulfide.

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* Communication No. 780 from the Kodak Research Laboratories.

In addition to attack of the silver image by hypo within the gelatin layer, many external agents are also effective, the most significant being hydrogen sulfide which is present in coal gas (illuminating gas). High humidity and temperature accelerate this reaction tremendously. Sulfur dioxide and other acid gases, in the absence of hypo, affect the silver image to a much less degree than hydrogen sulfide.

The rate at which a silver image fades depends upon many factors, including (1) the concentration of hypo (or tetrathionate) in the image layer, (2) the concentration of hydrogen sulfide and other acid gases in the atmosphere, (3) the grain size of the silver image, and (4) the temperature and humidity of storage.

Tests have shown that the degree of fading in a given time is roughly proportional to the concentration of hypo up to a certain limit, and a concentration as low as 0.005 milligram per square inch may cause fading with fine-grained images, especially in the case of papers.

An increase in the humidity, temperature, or both accelerates the rate of fading, and a combination of high humidity and high temperature, which conditions usually exist in tropical countries, is fatal to a photographic print containing hypo.

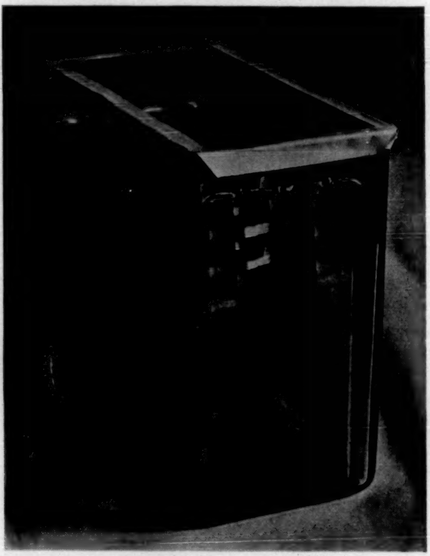
The presence of saline matter and acidic gases in the atmosphere also tends to increase the rate of fading.

Since fading or sulfiding of the image must necessarily take place initially at the surface of the image grains, fine-grained emulsions will tend to fade much more rapidly than coarser-grained emulsions and, in practice, chloride paper emulsions give images which are much more susceptible to fading than bromide emulsions. Similarly, a fine-grained positive transparency is much more susceptible to fading than an image on a high-speed negative emulsion.

Sodium thiosulfate tends to oxidize when exposed to the air with the formation of thionates and some sulfate. Certain recommended hypo eliminators oxidize hypo to sodium tetrathionate but the presence of this compound (and probably other thionates) is harmful because tetrathionate causes sulfiding of silver images almost as readily as hypo.

During this investigation it was essential to use an accelerated fading test in order to obtain directly comparable results within a reasonable time. Crabtree and Ross[1] have recommended the storage of test strips in a sealed glass container over water stored at a temperature of approximately 110° F. In the present investigation these storage conditions were maintained, the strips (negatives and prints) being suspended on glass rods in sealed glass containers, as shown in Fig. 1.

FIG. 1.



Apparatus for accelerated fading tests.

THE ESTIMATION OF HYPO IN PHOTOGRAPHIC MATERIALS.

A fallacy of the majority of investigations on hypo elimination has been the attempted estimation of the residual hypo by measurement of the hypo contained in the wash water. Testing solutions usually employed for this purpose are alkaline permanganate, iodine-azide, and mercuric chloride. These methods give a fairly accurate measure of the effect of washing upon "readily diffusible hypo" but they give no indication of the quantity of hypo retained by the photographic material.

In the case of images on glass or film, the hypo is usually removed quite readily by washing but, in the case of paper prints, it is extremely difficult, if not impossible, to remove all traces of hypo by washing alone. Apparently the thiosulfate ion is tenaciously held by the paper fibers and the baryta coating. A quantitative determination of the residual hypo in the photographic materials themselves is therefore necessary.

In 1908, Lumière and Seyewetz [2] recommended the use of silver nitrate as a spot test on prints and, again in 1935, Weyde [3] suggested the treatment of prints with silver nitrate to determine the hypo concentration, but no details of a quantitative standardization were given.

In the present investigation, the silver nitrate test was standardized in such a manner that the transmission density of a print bathed in silver nitrate was proportional to the quantity of hypo contained in the print and quantities as low as 0.005 milligram of hypo per square inch were determined successfully. The data obtained were also confirmed by a quantitative determination of the reducible sulfur in the paper.[4] With this method as a tool, a much more direct comparison of the effectiveness of many suggested "hypo eliminators" was possible.

With the usual permanganate test which consists in allowing the surplus water from a washed single-weight print to drain into a solution of potassium permanganate, a zero test is obtained when the silver nitrate test indicates the presence of about 0.2 milligram of hypo per square inch, a quantity which is capable of producing an objectionable degree of fading.

To determine the hypo in film, the mercuric chloride-potassium bromide test recommended by Crabtree and Ross[5] was used. A square inch of the material is placed in 10 cubic centimeters of the reagent and, after 15 minutes, the turbidity is compared with the turbidity produced in a series of standard solutions. This test accurately measures quantities of hypo in films as low as 0.005 milligram per square inch.

The mercuric chloride reagent was applied to prints, but found incapable of reacting with all of the hypo in the sample. Since only the hypo which diffuses out of the film or print contributes to the opalescence, the test measures only the "readily diffusible" hypo, whereas in the silver nitrate test, the silver nitrate reacts with all of the hypo within the film or print. Comparison of the results obtained with the mercuric chloride and the standardized silver nitrate test with prints is given in Table I.

TABLE I.

Comparison of Mercuric Chloride and Silver Nitrate Test with Photographic Prints.

Washed Prints (Minutes).		Hypo Content (Mg. per Sq. In.).	
Single-Weight.	Double-Weight.	Mercuric Chloride.	Silver Nitrate.
15		0.004	0.073
30		0.01	0.042
60		Trace	0.020
	15	0.02	0.320
	30	0.01	0.173
	60	Trace	0.134

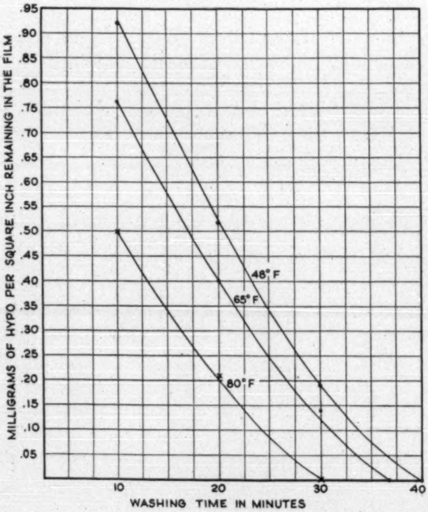
The Elimination of Hypo by Washing

The washing of photographic materials has always been accepted as a necessary operation but the importance of removing the last traces of hypo has often been underestimated.

Negatives.—For washing it is always preferable to use running water in a system such that an "ideal stream" prevails, that is, a sufficient volume of water passes over the surface of the material so that it removes the hypo from the surface of the emulsion faster than the hypo diffuses out. When washing in a tray in still water, the water must be changed often and the negatives agitated continually. Under ideal conditions of water renewal, the most important factors which affect the rate of washing of films are: (1) the temperature of the wash water, and (2) the composition of the fixing bath.

The curves in Fig. 2 illustrate the effect of the temperature of the wash water on the rate of elimination of hypo from

FIG. 2.



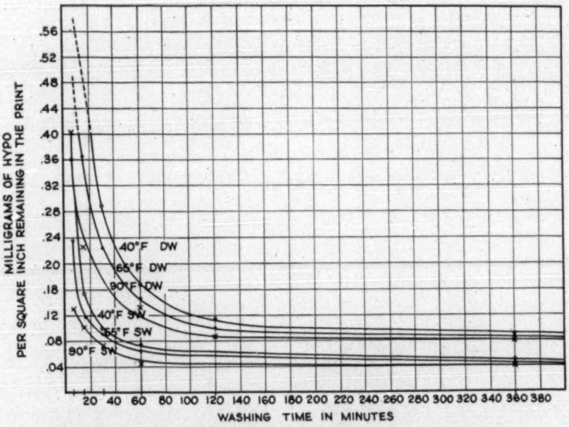
Effect of wash water temperature on rate of hypo elimination from Eastman Verichrome Film.

Eastman Verichrome film. The films were washed under "ideal" conditions of water flow and it is seen that a change in temperature from 40° to 65° F. increases the quantity of hypo removed in a given time of washing by about 33 per cent. whereas increasing the temperature from 65° to 80° F. almost doubles the quantity of hypo removed. A temperature of 60° to 70° F. is recommended in view of the danger of swelling and softening at higher temperatures.

The hypo was also more readily washed from film which had been fixed in a nonhardening fixing bath than from film fixed in a potassium alum fixing bath. The use of a chrome alum fixing bath resulted in washing times somewhat less than those for potassium alum-hardened negatives.

Prints.—Thorough washing is much more important in the case of prints than with negatives because fine-grained paper emulsions fade much more readily and, in some cases, in the presence of as small a quantity of hypo as 0.002 milligram per square inch. Not only is the image more susceptible to fading but relatively high concentrations of hypo are usually retained in the print. This retention of hypo is due to the presence of the paper fibers and the baryta coating and, since, even with extremely long times of washing with an "ideal stream of pure water," traces of hypo are retained in prints (especially with double-weight stock), it is apparent that the thiosulfate ion is probably mordanted or adsorbed to the fibers and baryta.

FIG. 3.

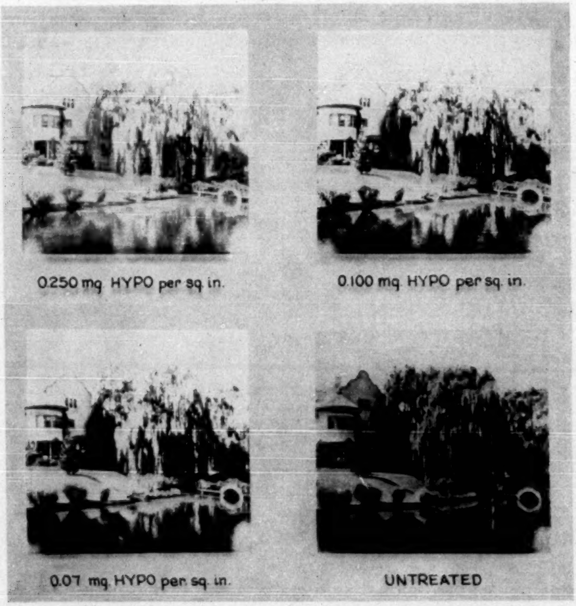


Effect of temperature of wash water on rate of elimination of hypo from single- and double-weight prints.

As in the case of negatives and assuming an "ideal stream" for washing, the two most important factors to be considered in the elimination of hypo from prints are: (1) the temperature of the wash water, and (2) the composition of the fixing bath.

In 1908, Lumière and Seyewetz[6] and in 1910, Hauberrisser[7] recommended the use of elevated temperatures during washing but, to date, no extensive practical application has been made of the suggestion. The curves in Fig. 3 show the effect of the temperature of the wash water on the rate of elimination of hypo from single- and double-weight prints.

FIG. 4.


0.250 mg. HYPO per sq. in.
0.100 mg. HYPO per sq. in.
0.07 mg. HYPO per sq. in.
UNTREATED

Accelerated fading tests illustrating the relative fading produced by decreasing concentrations of hypo. (Hypo content in milligrams per square inch—chloride emulsion.)

Single- and double-weight papers were washed for 20 hours, but the curves indicate that a maximum elimination is approached after 1 or 2 hours. The very great effect of temperature of the wash water is evident for the shorter washing times but is not so great for the longer times of washing. Washing for as long as 20 hours did not eliminate the last traces of hypo in either single- or double-weight papers. With extended washing, the rate of elimination tends to approach zero. The quantities of hypo retained after prolonged washing are sufficient to cause fading under certain storage conditions. It is evident, therefore, that use of a hypo eliminator is a necessity if the highest degree of permanence is desired.

The prints shown in Fig. 4 were washed for times sufficient to leave the designated quantities of hypo in them and were then stored under the accelerated fading conditions previously described. They illustrate the effect of increasing hypo concentration on the degree of sulfiding or fading of the image and emphasize the necessity for the complete elimination of hypo from papers coated with fine-grained chloride emulsions.

HYPO ELIMINATORS.

The term "hypo eliminator" was first used by Hart[8] to indicate a solution which was capable of oxidation of thiosulfate to neutral sulfate. Oxidizing agents only were known as eliminators but the term acquired general use and is now applied to any solution or chemical that either oxidizes the hypo or assists in its elimination.

Many chemical treatments have been proposed to assist in the elimination of hypo or to make photographic prints permanent. Some of these may be listed as follows: Alum (1855); hypochlorous acid (1864); hydrogen peroxide (1866); sodium hypochlorite (1866); ammonium carbonate (1866); iodine (1872); zinc hypochlorite (1881), known as Flandreau's eliminator; ammonium persulfate (1899); potassium percarbonate (1901); alkaline perborates (1903); potassium permanganate (1904); chloramine T (1922); alkali carbonate or phosphate (1923); dilute caustic soda (1925); peroxide and ammonia (1931); and 1 per cent. sodium carbonate (1935).* None of the suggested treatments has been generally accepted nor has any stood the test of time. It has been shown that none of these recommended treatments, even when used following careful washing was effective enough to eliminate the hypo completely. In several instances increased concentration of the constituents successfully oxidized the hypo but to the detriment of the silver image.

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* A chronological bibliography is given in the appendix.

Two general types were found to be particularly effective, namely (*a*) alkalies, and (*b*) oxidizing agents such as hydrogen peroxide-ammonia solutions.

Alkalies.—Norton and Crabtree,* working with paper prints, recommended the use of dilute sodium carbonate solutions immediately after the fixation process and previous to washing. However, in view of the danger of precipitation of alumina with fixing baths containing alum, it is considered desirable to wash negatives or prints before the alkali treatment.

(1) *Negatives.*—Various alkalies were found to assist in the elimination of hypo from negatives but they were not equally effective. A quantity of films was normally processed and washed for 8 minutes at 65° F. in running water, samples then being treated in distilled water, ammonium hydroxide, Kodalk, sodium hydroxide, and sodium carbonate solutions (0.3 per cent.) for 2 minutes. These samples were washed for 2 minutes, dried, and analyzed by the mercuric chloride method which indicated the following hypo contents in milligrams per square inch:

Untreated	0.06	mg. per sq. in.
Distilled water	0.02	" " " "
Ammonium hydroxide (0.3%) pH = 10.40	Nil	" " " "
Kodalk (0.3%) pH = 9.90	0.01	" " " "
Kodalk (0.3%) pH adjusted to 10.40	0.005	" " " "
Sodium hydroxide (0.3%) pH = 11.57	0.01	" " " "
Sodium hydroxide (0.3%) pH adjusted to 10.40	0.01	" " " "
Sodium carbonate (0.3%) pH = 10.48	0.005	" " " "

Ammonium hydroxide was the most effective alkali and it also had the least effect on the physical properties of the emulsion. In most instances, regardless of the alkali, the time required to wash out the hypo completely was reduced by more than 50 per cent.

(2) *Prints.*—An extensive study of the use of alkalies with

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* Eastman Kodak Laboratories, July 1923, unpublished results.

respect to the elimination of hypo from prints indicated that ammonia was the most effective alkali. Sodium metasilicate, sodium hydroxide, and ammonia at concentrations of 0.08 Molar* caused the complete elimination of hypo from prints which had been washed in an "ideal" stream of water for 15 minutes at 65° to 70° F., but the hydroxide and metasilicate produced severe physical defects in the print. Ammonia could be effectively used at room temperature and did not damage the prints. However, the time of 45 minutes required for treatment was excessive.

Peroxide-Ammonia. (1) *Negatives.*—The use of hypo eliminators, other than alkalies, is not usually required in the processing of negative materials. However, the hydrogen peroxide-ammonia eliminator recommended below for prints is applicable to film emulsions also but must be used in lower concentrations (diluted 1 : 10) because of the tendency to soften and blister the emulsion.

(2) *Prints.*—The outstanding fault with the majority of oxidizing agents proposed for hypo elimination is their acid character or their need for an acid medium. An alkaline peroxide solution, on the other hand, is a very effective oxidizing agent for sodium thiosulfate and does not attack the silver image even in quite high concentrations.

Hydrogen peroxide itself was recommended as early as 1866 by Smith[9] to be used in a dilution of 1 : 1000 for a minute or two. He later suggested that the acid in the peroxide be neutralized with soda. About the same time Spiller[10] reported an attempted use of a mixture of hydrogen peroxide with ammonia but declared that such a mixture was unsatisfactory because the two constituents "mutually decomposed." Subsequent workers reported that hydrogen peroxide itself did not oxidize all of the hypo to sulfate but produced some thionates. This is actually the case but alkaline peroxide having a suitable pH value oxidizes the thiosulfate completely to sulfate.

In 1931, a note in *Das Lichtbild*[11] mentioned the use of hydrogen peroxide as a hypo eliminator. Here, ammonia was added dropwise until the solution just smelled of ammonia, an adjustment which corresponds to that of Smith who used soda to neutralize the acid in the peroxide. It is evident, then, that the previous use of hydrogen peroxide was concerned with neutral hydrogen peroxide.

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* In grams per liter—sodium metasilicate (crystal), 17 grams; sodium hydroxide, 3.2 grams; ammonia (28%), 5 cubic centimeters.

Experiments in these Laboratories have shown that definitely alkaline peroxide solutions will oxidize sodium thiosulfate completely to sulfate and the study of alkalies in hypo elimination has shown that ammonia is the most suitable alkali for this purpose. It has the additional advantage that it is volatile, so that, after treatment, the only residue is a trace of sodium and ammonium sulfates. An investigation was therefore made of ammonia-peroxide solutions to determine their activity in the elimination of hypo from prints.

At the outset, mixtures of peroxide with increasing concentrations of ammonia were prepared to determine the pH range of the solution over which effective oxidation of hypo was attained (see Table II).

TABLE II.

Change in pH with Increased Ammonia Concentration.

Composition of Solution (Cc. per Liter).			pH Glass Electrode.
H_2O_2 (3%).	Water.	Ammonia (28%).	
500	500	—	3.7
500	500	0.6 (Das Lichtbild)	9.0
500	500	2.0 (Marked odor)	9.3
500	500	10.0	9.8
250	750	10.0	9.95
125	875	10.0	10.15
—	1000	10.0	10.75

Solutions having a pH value lower than 9.8 were not entirely satisfactory as hypo eliminators because of their low activity. The three solutions containing 500, 250, and 125 cubic centimeters of 3 per cent. peroxide per liter with 10 cubic centimeters of 28 per cent. ammonia in each were compared throughout the study. Dilutions with water of any of these solutions produced mixtures which would not efficiently remove the last traces of sodium thiosulfate. Table III illustrates typical results obtained by treatment in these solutions for different times after increasing times of washing.

It is apparent from Table III that, if double-weight prints are washed for 20 minutes and then bathed for 10 minutes in the eliminator solution, the hypo is completely eliminated from the prints in the case of all three of the above solutions containing varying quantities of peroxide. The disadvantage of the 125/10 peroxide-ammonia mixture is its shorter exhaustion life as compared with the 500/10 mixture. For single-weight prints, a shorter wash will suffice. All prints must be washed for at least 5 to 10 minutes after the eliminator treatment.

TABLE III.

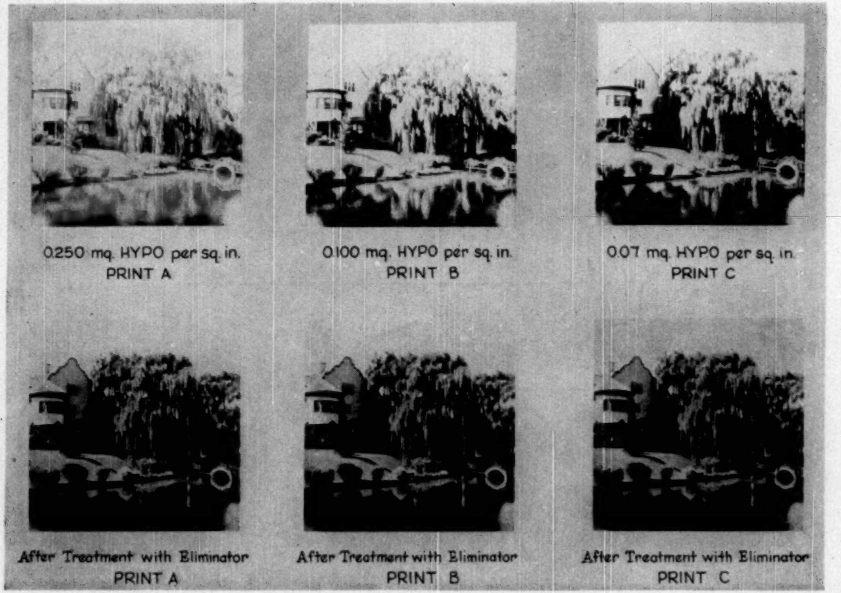
The Elimination of Hypo from Double-Weight Prints with Peroxide-Ammonia.

Peroxide-Ammonia (Cc. per Liter).	Time of Washing (Min.).	Time of Treatment (Min.).	Hypo Concentration (Mg. per Sq. In.).
500 + 10 (Peroxide) (Ammonia) 3% 28%	10	5	0.040
		10	0.006
		15	Nil
	20	5	0.004
		10	Nil
	30	5	0.004
		10	Nil
250 + 10 (Peroxide) (Ammonia) 3% 28%	10	5	0.038
		10	0.007
		15	Nil
	20	5	0.008
		10	Nil
	30	5	0.007
		10	Nil
125 + 10 (Peroxide) (Ammonia) 3% 28%	10	5	0.055
		10	0.007
		15	Nil
	20	5	0.006
		10	Nil
	30	5	0.005
		10	Nil

A duplicate set of the prints shown in Fig. 4 was treated in a hydrogen peroxide solution for 5 minutes, washed for 5 minutes, and then subjected to the accelerated fading test at the same time as the prints which were not treated in the eliminator solution. The effect of the peroxide-ammonia eliminator in preventing fading is illustrated in Fig. 5.

An extensive study of the application of these solutions in the photographic trade was made with special attention

FIG. 5.


0.250 mq. HYPO per sq. in.
PRINT A
0.100 mq. HYPO per sq. in.
PRINT B
0.07 mq. HYPO per sq. in.
PRINT C
After Treatment with Eliminator
PRINT A
After Treatment with Eliminator
PRINT B
After Treatment with Eliminator
PRINT C

Accelerated fading tests illustrating the effectiveness of the peroxide-ammonia hypo eliminator. The upper row of prints contained quantities of hypo designated in milligrams per square inch and did not receive eliminator treatment. The lower row of prints contained same quantities of hypo and were treated 5 minutes in an eliminator solution consisting of 500 cc. of 3 per cent. hydrogen peroxide and 10 cc. of 28 per cent. ammonia per liter. They were then subjected to the same accelerated fading conditions. Note absence of fading.

to exhaustion life of the solutions, and to any possible deleterious effects in commercial processing. The specific application is dependent upon the use intended. At the outset, since it is never possible to predict the conditions to which a print may be subjected, every photographer must eliminate the hypo completely from prints and negatives, even if this may require some slight modification of his processing machine or the method of working.

PRACTICAL RECOMMENDATIONS.

With negatives and transparencies or, in general, any gelatin silver image on a waterproof support, if, during washing, an adequate renewal of the wash water prevails, the hypo can be removed completely by water alone in a reasonable time at a temperature of 60° to 70° F. without the use of a hypo eliminator.

If it is necessary to speed up the processing by using a shorter washing time, a supplementary alkaline bath may be used. After the negatives have been washed for 10 minutes, they should be bathed in an 0.3 per cent. solution of ammonium hydroxide (100 cubic centimeters of 28 per cent. ammonia per liter) for 3 minutes and then washed for 2 or 3 minutes.

The rate of washing is also hastened if a chrome alum or nonhardening fixing bath is employed.

With photographic prints, washing is hastened by using water at around 70° F., but it is never possible to remove the hypo completely by merely washing so that the print will not subsequently fade if subjected to abnormal conditions of temperature and humidity. The use of the following peroxide-ammonia eliminator is necessary to insure permanency:

KODAK HE-1.

Hypo Eliminator Solution for Professional and Amateur Use.

	Avoirdupois.		Metric.
Water	16	ounces	400.0 cc.
Hydrogen Peroxide (3% solution)	4	fluid oz.	125.0 cc.
Kodak Ammonia (3% solution)	3¼	fluid oz.	100.0 cc.
Water to make	32	ounces	1.0 liter

To make 3 per cent. ammonia, dilute 1 part of 28 per cent. ammonia with nine parts of water.

Directions for Use—Wash the prints for about 30 minutes at 65° to 70° F.* in running water which flows rapidly enough to replace the water in the vessel (tray or tank) completely once every 5 minutes. Then immerse each print about 6 minutes at 70° F. in the Hypo Eliminator Solution (Kodak HE-1), and finally wash about 10 minutes before drying.

Life of Kodak HE-1 Solution—About fifty 8-inch × 10-inch prints or their equivalent per gallon (4 liters).

Test for Hypo—Process with the batch of prints, an unexposed *white* sheet of photographic paper (same weight and size as majority of prints in batch). After the final wash, cut off a strip of this sheet and immerse it in a 1 per cent. silver nitrate solution for about 3 minutes; then rinse in water and compare, *while wet*, in subdued daylight or artificial light, with the *wet, untreated portion*. If the hypo has been completely removed, no color difference should be observed. A yellow-brown tint indicates the presence of hypo.† *Caution:* Silver nitrate solution stains the skin black; avoid direct contact with the solution.

KODAK HE-2.

Hypo Eliminator Solution for Commercial Photofinishing Use.

	Avoirdupois.	Metric.
Water	10 ounces	300.0 cc.
Hydrogen Peroxide (3% solution)	16 ounces	500.0 cc.
Kodak Ammonia (3% solution)	3¼ ounces	100.0 cc.
Water to make	32 ounces	1.0 liter

To make 3 per cent. ammonia, dilute 1 part of 28 per cent. ammonia with nine parts of water.

Directions for Use—Wash the prints about 15 minutes at 65° to 70° F.‡ in running water which flows rapidly enough to replace the water in the washing vessel (tray or tank) completely once every 5 minutes. Then immerse each print for about 5 minutes in the Hypo Eliminator Solution (Kodak HE-2), and finally wash about 10 minutes before drying.

When using a Pako Print machine (or similar equipment), replace the water in the second wash tank with the Hypo Eliminator Solution (Kodak HE-2), and process the prints as usual.

Life of Kodak HE-2 Solution—About eighty 8-inch × 10-inch prints or their equivalent per gallon (4 liters).

Test for Hypo—Use the same test as recommended for use with Kodak HE-1 Solution.

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* For lower temperatures, increase the washing time. Double the washing time should be used when double-weight prints are treated.

† A positive test with silver nitrate may also be obtained in the absence of hypo, if hydrogen sulfide or wood extracts are present in the water supply.

‡ For lower temperatures, increase the washing time. Double the washing time should be used when double-weight prints are treated.

OCCASIONAL EFFECTS WHEN USING THE PEROXIDE-AMMONIA TREATMENTS HE-1 AND HE-2.

1. A slight change in tone. This tone change is not as great as that produced by ferrotyping and, therefore, is considered to be negligible for glossy papers. When it is desired to prevent the slight tone change on professional papers, 15 grains of potassium bromide should be added to each quart (1 gram per liter) of the Kodak HE-1 bath.
2. A slight yellowing of the whites (undetectable on buff papers). To minimize this effect, the prints should be bathed in either a 1 per cent. acetic acid solution or a 1 per cent. sodium sulfite solution for about 2 minutes immediately after treatment in HE-1 or HE-2 and prior to the final wash.
3. If the prints feel too slippery after the eliminator, they should be immersed for 1 minute in a 1 per cent. solution of acetic acid and then washed for 3 or 4 minutes.
4. A slight tendency for treated prints to stick to a hot belt dryer. To prevent this, the prints should be bathed prior to drying, for 3 to 5 minutes in a 50 per cent. denatured alcohol solution. A 2 per cent. potassium alum solution is effective but requires a rinse of several minutes in water after the treatment.
5. An occasional tendency for treated glossy prints to ride the squeegee roll of the ferrotype dryer (especially prints which have been accidentally fed into the machine emulsion side up), or to stick to the chromium drum itself. To overcome these difficulties, the prints should be bathed for 2 minutes in a 50 per cent. denatured alcohol solution just prior to ferrotyping.
6. While cleanliness of the drum surface is essential for the satisfactory ferrotyping of all prints, it is especially important as a sticking preventive in the case of peroxide-ammonia treated prints. Excessive drum temperatures should also be avoided.

The above treatment will insure the absence of fading from internal fading agents. However, a hypo-free image will be attacked by hydrogen sulfide which is present in the products of combustion of coal gas and in the atmosphere of industrial regions. This external fading is accelerated by the presence of acidic gases and by high temperature and high humidity.

The use of water-miscible (paste) adhesives for mounting also contributes to fading, since such adhesives are usually hygroscopic and the resulting moist condition of the print is favorable to more rapid chemical reaction.

Fading due to external agents may be minimized by (1) the use of a waterproofing lacquer over the print surface, (2) the use of Dry Mounting Tissue, and (3) bathing the print in a solution of a salt of a noble metal, such as gold chloride (with sodium thiocyanate), when the metal ion displaces the outer layer of the silver grains, usually with a negligible change in image color. A suitable formula consists of gold chloride, 0.1 gram; sodium thiocyanate, 10 grams; dissolved in 1 liter of water.

It is essential that the solution be prepared just before use and in the following manner: Add 10 cubic centimeters of a 1 per cent. gold solution to a 1-liter vessel and dilute to approximately 700 cubic centimeters. Dissolve the thiocyanate in a small volume of distilled water and add slowly to the gold solution with continuous agitation. Then make up to 1 liter with water.

Bathe either the freshly washed or dried prints for 8 minutes at 70° to 75° F. with agitation or until a just perceptible change in tone occurs and then wash for 5 minutes before drying. The life of the bath if used immediately is approximately thirty 8-inch × 10-inch prints per gallon of solution.

The gold treatment also stabilizes the image against fading by hypo. It is not quite as effective, however, as the peroxide-ammonia treatment and has the disadvantage that the color of the image is changed slightly.

With respect to fading by hydrogen sulfide, lacquering the print surface is helpful but not as effective as the gold treatment. Dry Mounting in combination with a lacquer is surprisingly effective from which it is apparent that the hydrogen sulfide attacks the image appreciably from the rear through the paper stock as well as at the surface.

A combination of these procedures, namely (1) use of the peroxide-ammonia hypo eliminator, (2) treatment with the gold solution, (3) the use of Dry Mounting Tissue, and (4) lacquering of the print surface, will insure maximum permanency of the gelatin silver print image. Conversion of the silver image to silver sulfide by sulfide toning in the usual manner, or to silver selenide or telluride, will also insure maximum permanency, although such treatments change the color of the image.

RELATION BETWEEN THE THEORETICAL AND PRACTICAL QUANTITIES OF HYPO REQUIRED TO PRODUCE FADING.

It is of interest to study the relationship between the theoretical quantity of sodium thiosulfate required to convert any given silver image to silver sulfide and the quantities actually required to produce fading under accelerated conditions in practice.

The "photometric equivalent" [12] may be defined as the number of grams of silver in a 100 square centimeter area of emulsion which are necessary to give a density of 1.00. Its magnitude varies with the exposure, the degree of development, and the grain size of the emulsion, ranging from approximately 0.005 to 0.035, depending upon the type of the emulsion.

Hickman and Spencer [13] calculated the quantity of thiosulfate required to react with the silver in an image having a density of 0.10 and made the assumption that only one-tenth of the silver need be sulfided to produce just visible fading, which seems reasonable. The reaction may be expressed by the equation—

$$\underset{\text{Silver}}{2Ag^+} + \underset{\begin{array}{c}\text{Thiosulfate}\\\text{ion}\end{array}}{S_2O_3^=} \rightarrow Ag_2S + \underset{\begin{array}{c}\text{Silver}\\\text{Sulfide}\end{array}}{SO_3^=}$$

To express the quantity of thiosulfate in milligrams per square inch which is required to fade an image of density 0.10, the following formula was employed:

$$\begin{array}{c}\text{Photo-}\\\text{metric}\\\text{Equiva-}\\\text{lent}\end{array} \times \frac{\begin{array}{c}\text{Molecular Weight}\\\text{of Sodium}\\\text{Thiosulfate}\end{array}}{\begin{array}{c}2 \times \text{Atomic Weight}\\\text{of Silver}\end{array}} \times \begin{array}{c}\text{Conversion}\\\text{Factor}\\\text{Metric}\\\text{to Avoir.}\end{array} \times 10\% \times 0.1$$

$$\text{Photometric Equivalent} \times \frac{248}{215} \times \frac{6.45 \times 0.1 \times 0.1}{100 \times 1000}$$

The sulfiding reaction first occurs visibly in the low densities having a value of approximately 0.10. The photometric equivalents at low densities are given in Table IV and also the theoretical quantity of thiosulfate required to produce fading at a density of 0.10. Included in the same table are limiting concentrations of hypo above which fading occurred under the conditions of the accelerated fading test.

TABLE IV

Material.	Density at Which Photometric Equivalent Was Measured.	Photometric Equivalent at Indicated Density.	Calculated Quantity of Hypo (Mg. per Sq. In.) Required to Cause Fading at Density of 0.1.	Concentration of Hypo Required in Practice* (Mg. per Sq. In.).
Chloride paper emulsions	—	—	0.005†	0.002–0.005
Chlorobromide paper emulsions‡	0.25	0.0087	0.007	0.02
	0.08	0.009	0.007	
Fine-grain lantern slide [15]	1.00	0.005	0.008	0.02
Fine-grain emulsion	0.47	0.0108	0.008	
Process emulsion [14]	0.13	0.0153	0.011	0.07
Process emulsion [14]	0.09	0.0235	0.018	
Commercial emulsion [14]	0.13	0.0226	0.017	0.14
	0.56	0.0228	0.017	

* These figures represent average values for the types of materials mentioned.

† Chloride emulsions are more fine-grained than chlorobromide emulsions and the photometric equivalent is probably as low as 0.005.

‡ Unpublished results—S. E. Sheppard and A. Ballard, Kodak Research Laboratories.

In general, the faded images with the intermediate and high-speed materials possessed a purplish-black coloration not greatly different in appearance from the original and often of similar printing density. The images of motion picture positive emulsions became more yellowish-brown than those of the high-speed materials but only when the hypo content was in considerable excess of 0.07 milligram per square inch. With the finest-grained materials, a definite yellowing occurred at concentrations of thiosulfate greater than 0.02 milligram per square inch.

A comparison of the theoretical values given in Table IV with the quantities determined by experiment reveals that (1) with chloride paper emulsions the hypo content should not exceed 0.002 to 0.005 milligram per square inch or 0.02 milligram per square inch with chlorobromide emulsions; and (2) with film emulsions, in general, more hypo is allowable than the calculated theoretical value, for example (*a*) fine-grain materials 2 to 3 times, and (*b*) with negative materials, 4 to 9 times. This indicates that when a safety factor of 10 is assumed in the determination of the quantities of hypo required to fade images, in general, the formula is applicable only to paper emulsions. With film emulsions, it is apparently necessary to convert from 25 to 50 per cent. of the total mass of the image to silver sulfide before the image color changes appreciably.

All of the types of emulsions mentioned are readily washed to the degree indicated in Table IV and, in good commercial practice, are usually washed to concentrations well below those given. Process, motion picture positive, and fine-grain emulsions, for example, often contain as little as 0.005 milligram per square inch, as determined by the Crabtree-Ross method. This method of analysis has been adopted by the National Bureau of Standards.[16]

ACKNOWLEDGMENT.

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CHRONOLOGICAL HISTORY OF HYPO ELIMINATORS.

1855—Alum—"On Positive Printing," by J. Newton. (*J. Phot. Soc.*, **31**: 176, June, 1855.) ". . . immerse in hyposulfite for about 2 or 3 minutes, then in alum water for half an hour and change the water entirely two or three times."

1855—Caustic Potash—"Communication on Positive Photographs" by Mr. Malone. (*J. Phot. Soc.*, **31**: 177, June, 1855.) "I suggest that you should treat the positive photograph, fixed in the ordinary way, with a strong solution of caustic potash heated to about 180° Fahrenheit; . . . carefully washing out the potash."

1856—Dilute Alkali or Alkaline Carbonate—"Photographic Chemistry," by F. Hardwick (Churchill, London, Third Edition, page 170, 1856). ". . . and the removal of the size which can be effected by means of a dilute alkali or an alkaline carbonate, . . . has the additional advantage of carrying out the last traces of hyposulfite of soda. . . ."

1864—Hypochlorous Acid—"Minutes of Meeting of South London Photographic Society," by F. W. Hart (*B. J. Phot.*, **11**: 82, March, 1864). Suggested the use of chlorine and barium chloride in aqueous solution to convert hypo to barium sulfate and sodium chloride.

1866—Hydrogen Peroxide—"On the Removal of the Last Traces of Hyposulfites from Positive Paper Prints," by A. Smith (*B. J. Phot.*, **13**: 226, May, 1866). Recommended the use of hydrogen peroxide, diluted with one thousand times its volume of water, for one or two minutes. He advised the neutralization of the acid in the peroxide with soda. The treatment required a rinse in water as the final operation.

1866—Hydrogen Peroxide and Ammonia—"Photography in Its Chemical Aspects," by J. Spiller (*Phot. J.*, **11**: 58, June 1866). Used hydrogen peroxide with ammonia but claimed that the two were "mutually decomposed." Then suggested treating first in hydrogen peroxide followed by ammonia. *Note:* A discussion of this paper, reported in *B. J. Phot.*, **13**: 283–284, 1866, recommended treating the prints first in ammonia and then in hydrogen peroxide.

1866—Sodium Hypochlorite—"On the Elimination of the Double Hyposulfites of Soda and Silver from Photographic Prints," by F. W. Hart (*B. J. Phot.*, **13**: 290, June, 1866). Recommended sodium hypochlorite followed by very dilute ammonia to dissolve traces of silver chloride.

1866—Chloric and Perchloric Acids—Editorial—"Permanent Prints: A New Plan," by Messrs. Tichborne and Robinson (*B. J. Phot.*, **13**: 580, Dec., 1866). Twenty-four grains of barium chlorate are dissolved in one ounce of water and 20 minims of 12 per cent. perchloric acid added. For use add 2 ounces of this solution to one pint of hot water. Treat prints for about an hour and wash in water.

1872—Iodine—"The Chemistry of Photography," by W. Harrison (The Scovill and Adams Co., New York, N. Y., p. 412, 1892). Vogel is credited with the first use of iodine. After careful washing the prints were placed in water to which enough iodine solution was added to give it a sherry color; then rinsed in a very weak solution of sulfite and sodium carbonate to remove the blue color and finally washed in water.

1881—Alum—"Notizen zum Bromsilber—Gelatine Verfahren," by J. M. Eder (*Phot. Korr.*, **18**: 203, 1881). Used a saturated solution of alum diluted one to ten with water.

1881—Zinc Hypochlorite—Messrs. L. Belitzski and G. Scolik (Eder's Handbuch, Part III, Knapp, Halle (4th edition) 317, 1890). Used in dilute water solution. Known as Flandreau's eliminator in America.

1883—Bromine Water, Etc.—"Die Beseitigung des unter schwesligsauren Natrons," by F. Stolze (*Phot. Wochenblatt*, p. 348, 1883). Javelle water, hydrogen peroxide, iodine water, bromine water, lead nitrate, and barium nitrate are discussed. Alum with citric acid in water was suggested. Successive five-minute treatments were used and the wash water tested after each wash. None of these was considered entirely satisfactory.

1888—Hypo Eliminator—"Early History of Hypo Eliminators," by F. W. Hart (*B. J. Phot.*, **35**: 151, 1888). The claim to the original use of the term "hypo eliminator" is made.

1889—Sodium Chloride—Editorial (*American Photography*, **19**: 38, 1889). Reference to the use of sodium chloride as an eliminator by Dr. Bannon but no directions are given.

1894—Potassium Persulfate. Mention of its use by Schering is made by L. P. Clerc in his book "Photography—Theory and Practice," Pitman, London, page 269, 1930.

1897—Iodated Salt—"Sel Iode Eliminateur Rapide des Hyposulfites," by M. P. Mercier (*Bull. de la Soc. Franç. de Phot.*, **30**: 296, 1897). A suggested formula was iodine 3 parts, salt 30 parts, and sodium carbonate 30 parts dissolved in 1000 parts of water. "Decolorize with ammonia just before use. The print may be left in this solution for a long time because the colorless solution does not attack the silver image. Iodine or iodides may be used with alkali or alkali salts and bromine or bromides may be used but the latter are much slower acting."

1901—Potassium Percarbonate—Use by G. Meyer is mentioned by L. P. Clerc in his book "Photography—Theory and Practice," Pitman, London, page 269, 1930. No directions are given.

1902—Ammonium Persulfate—"Use of Various Oxidizers for the Destruction of Hypo," by A. and L. Lumière and A. Seyewetz (*Bull. de la Soc Franç. de Phot.*, **10**: 270, 1902). Hydrogen peroxide, potassium percarbonate and commercial ammonium persulfate were the best hypo oxidizers but ammonium persulfate was the most practical provided the free acid was first neutralized with either carbonate, bicarbonate, alkaline phosphates, alkaline citrates, alkaline tungstate or borax. Low concentrations were satisfactory.

1903—Alkaline Perborates—G. F. Jankert. Mentioned by L. P. Clerc in his book "Photography—Theory and Practice," Pitman, London, page 269, 1930. No directions given.

1903—Sodium Chloride—O. Baysellance (*Phot. Rev.*, **12**: 32, July 26, 1903). "Treat 1/2 to one hour in 3 per cent. sodium chloride and then give three or four rinses in water."

1904—Potassium Permanganate—"Permanganate as an Eliminator of Hypo," by I. Pearse (*J. Phot. Soc. India*, 1904. Cf. *Photography*, **20**: 197, 1905). Use water slightly colored with permanganate and use successive solutions until no change in color occurs. Less than ten minutes of this treatment was equal to two hours washing.

1912—Bisulfite-Formaldehyde—"A Hypo Remover," by E. D. Davison (*Camera Craft*, **19**: 30, 1912). Recommended water 40 parts, sodium bisulfite 3 parts, and formaldehyde 8 parts. Treat prints (after washing) for 10 to 15 minutes in a solution diluted 1 : 3 with water.

1922—Chloramine T (Sodium *p*-toluene Sulfochloramide)—"A New Quick Clean Eliminator of Hypo," by E. F. Shelberg (*Amer. Phot.*, **16**: 267, April, 1922). Dissolve one tablet in 40 oz. water and treat for two or three minutes, washing before drying.

1923—Dilute Sodium Carbonate—Unpublished data on the use of alkalies in hypo eliminator by F. J. Norton and J. I. Crabtree (Kodak Research Laboratories), July–August, 1923. Dilute solutions of sodium carbonate were recommended for use immediately after fixing.

1923—Alkali Carbonate or Phosphate—"Adsorption of Sodium Thiosulfate by Photographic Paper," by A. Charriou (*Comp. Rend.*, **177**: 482–484, 1923). Claimed that hypo was displaced more readily by washing in a solution of alkali carbonate or phosphate than by water.

1925—Ferrous Sulfate—"Hypo Eliminators and Intensifiers." British Patent 225,664, Oct. 9, 1923 (*B. J. Phot.*, **72**: 24, 1925). Three parts ferrous sulfate and one part sodium chloride were thoroughly mixed. Prints were treated in a solution containing 8 grains of this mixture in 1½ pints of water and washed before drying.

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1925—Sodium Hydroxide—"Hypo Eliminator," by A. E. Amor (*B. J. Phot.*, **72**: 18–19, 1925). Claimed that 0.2 per cent. sodium hydroxide and a persulfate formula of the following composition were most effective eliminators but neither was an improvement over careful washing: Persulfate 6 grams, sodium carbonate 12 grams, water 1000 cubic centimeters.

1931—Sodium Hypochlorite Plus Sodium Chloride—R. Namias (*Il prog. fot.*, **38**: 125, 1931). This combination was an improvement over hypochlorite alone. Negatives were washed five minutes, treated in 0.3 per cent. sodium hypochlorite plus 1 per cent. sodium chloride solution and washed for one or two minutes.

1931—Hydrogen Peroxide Plus Ammonia—Note in *Das Lichtbild*, **7**: 42, 1931. Ammonia was added dropwise until the solution just smelled of ammonia.

1932—Dilute Caustic Soda—"The Use of Alkalies as Hypo Eliminators," by E. E. Jelley (*Phot. J.*, **72**: 480–485, 1932). Kodak Research Laboratories Communication No. 503H.

1937—Sodium Carbonate 1 per cent.—"On the Possibility of Improving the Permanence of Photographic Prints," by E. Weyde (*Veröff. wiss. Zentral-Lab. phot. Abt. Agfa*, V: 181–186, 1937). Also *B. J. Phot.*, **82**: 376, June 14, 1935 and *Photo Woche*, **25**: 474, 1935. For best hypo elimination the use of a nonhardening fixing bath followed by bathing in 1 per cent. sodium carbonate before washing was recommended.

Cyanamid's Acrylonitrile.—B. W. HENDERSON. (*Chemical Industries,* Vol. 47, No. 1.) Recent research has resulted in the announcement by the American Cyanamid and Chemical Corporation that the commercial production of acrylonitrile of a high degree of purity is already under way. Acrylonitrile, which has never before been offered in this country in commercial quantities, is an essential intermediate in the production of some newer types of synthetic rubbers, especially those highly oil-resistant ones which, for several reasons, appear to have exceptional potentialities for replacing natural rubber if the need should arise. This development assures an adequate domestic supply of this chemical in commercial quantities, and opens up new fields for the synthetic rubbers. The future of acrylonitrile is so promising that Cyanamid is already making plans to double production capacity in order to anticipate demand. AERO Brand Acrylonitrile is a colorless liquid with a mild odor boiling at 77° C. (760 M.M.). The research studies connected with its production have cleared up some misconceptions about its properties. It is stable on long storage, noncorrosive, and can be safely shipped in steel drums without decomposition or premature polymerization. These rather unexpected properties are undoubtedly the result of its extremely high degree of purity which is essential in the production of synthetic rubbers. Even traces of impurities may have a harmful effect on copolymerization of acrylonitrile with butadiene. A trace of copper or of certain amines inhibits the reaction completely. Other impurities accelerate it so much that it cannot be handled. Cyanamid's success in achieving this purity has been remarkable. The results obtained by applying all available analytical methods to a single sample actually show more variation than the results obtained on different plant samples.

R. H. O.

PROGRESS OF THE BIOCHEMICAL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE.

BY

DR. ELLICE McDONALD,
Director.

The Biochemical Research Foundation, in its fifth year, has gone forward with studies of the biochemical and physicochemical phases of disease, medication and longevity. The inconveniences and delays incident to removing the laboratory to its new building in Newark, Delaware, have not seriously interrupted the progress of the research. A description of this new building will be presented in detail elsewhere.

The research activities, *per se*, have been paralleled by further experiment in research organization. The mechanism of coöperation in scientific investigation has always been of major interest to us and the correlation of research has been developed along new lines during the past year. Heretofore the department was the unit for achieving coöperation; in an endeavor to attain closer correlation the rigid division into departments was eliminated. Under the new scheme, a round-table conference takes the place, in part, of the former department heads. Each member of this conference represents the group engaged in one particular phase of research so that in this way a fan-like arrangement results in which all radii converge upon a focal point, the Director. This set-up enables the individual investigator to exercise his initiative and ability while at the same time the Director is closely connected with each worker and each investigation.

The advantages of this new arrangement were emphasized in the studies of bactericidal agents obtained from soil bacilli. In the course of work on the encapsulation of Friedländer's bacterium a substance was isolated from soil bacilli which inhibited encapsulation and at the same time was highly bactericidal for Gram-positive micro-organisms. This discovery, incidentally, might well be said to be a blessing of *serendipity*—a happy and unexpected discovery made by accident.

The beneficial and therapeutic possibilities of the substance isolated from soil bacilli are so far-reaching that a thorough investigation of its properties, structure and applications was necessary, and as the scope of such investigation was beyond that of an individual the different phases of this research were conducted by various members of the Staff.

The substance discovered by a micro-biologist to have bacteriostatic and germicidal qualities was naturally obtained at first in crude form. It was passed to the bacteriologists and cytologists to determine its qualities and powers, to the micro-chemists for analyses, identification and determination of probable composition, to the organic chemists for fractionation, to the spectroscopists for characterization and for determination of spectrographic differences between the various fractions obtained by the chemists, to the cytologists for toxicity and other experiments on animals, to the microscopists for record of crystalline structure of various fractions, to the surgeons for study of its external effects upon badly infected wounds, to the physical chemists for measurement of physical constants and further study as to its structure.

This is only one of the problems that called for and demonstrated the value of coöperation in research. The necessity for and the advantages of coördination and correlation of effort in research are evident in the problems presented and the progress made during the year.

Physico-chemical Properties of Giant Molecules.—There are two particularly important groups of giant molecules encountered in biochemical research: proteins and polysaccharides. The significance of such physical factors as size and shape of these giant molecules has been made clear by a great many investigations in recent years, especially those receiving their stimulus from the ultracentrifugal and related technics developed and extensively applied by Svedberg. The proteins have received a great deal of attention, but the polysaccharides, particularly those of importance for animal life, have been almost completely neglected. We are engaged in a physical study of one such polysaccharide, namely that of pneumococcus Type I. More satisfactory information on the size and shape characteristics is expected to throw light on the mechanism of the interaction between the polysaccharide and antibodies. We have found, as perhaps might be expected from similar studies made on cellulosic materials, that the pneumococcus polysaccharide as now commonly prepared contains a rather wide range of molecular weights, and that the size and range varies appreciably with apparently minor variations in method of preparation, without corresponding differences in serological activity. Preliminary estimates indicate that the molecular weight is of the order of magnitude of 100,000–200,000. This must be considered a tentative value since the molecule carries a considerable negative charge owing to its uronic acid nature and it is not yet certain that the effect of charge has been completely repressed. In order to extend this work, we have during the year constructed and installed a Lamm diffusion apparatus, to secure the best possible values for diffusion constants, for combination with sedimentation constants to give molecular weight values.

We have also added to the oil-turbine ultracentrifuge a so-called scale-projection unit in order that mixtures and high concentrations may be more satisfactorily studied. For investigations of molecular shape, properly made viscosity determinations are quite effective, and corresponding studies of the intrinsic viscosity of the polysaccharide in various media and under various conditions are in progress. Considerable attention has likewise been given to the theoretical analysis of the effects upon viscosity behavior of solvation, shape, and heterogeneity.

During the year, a rather brief ultracentrifuge study was made of the proteins in an ascitic fluid collected from a cancer patient. A corresponding electrophoretic investigation was also carried out. It was found that the protein content of the fluid was 3.4 per cent. and the ratio of albumin to globulin was about 1, which is in general agreement with published results obtained by conventional salt-fractionation of the protein.

A so-called analytical cell has been constructed. This will permit the determination of sedimentation constants of proteins which can not be analyzed by the usual optical methods, but which require removal from the centrifuge for chemical or biological assay.

Ultracentrifuge Studies.—One of the major physico-chemical projects is the development of the air-driven ultracentrifuge as a tool for the fractionation of proteins in biological fluids. The work carried on during this year has been a continuation of that begun two years previously.

During this period the laboratory has been interested in the use of the ultracentrifuge in the purification of serum antibodies. It was found that under laboratory controlled conditions one could increase the ratio of antibody to total protein by a factor of 6 with the aid of the ultracentrifuge. It was readily apparent, however, that the method of purification would meet with indifferent success under routine conditions such as might be encountered in the commercial plant. Subsequent to these findings the work has followed two lines: the development of technics for fractionation of proteins by means of selective or semi-specific aggregation aided by ultracentrifugation, and improvements in design of ultracentrifuges to meet requirements of routine use.

Experiments on the ultracentrifugal fractionation of antipneumococcus serum are being continued; it is recognized, however, that the demand for concentrated horse antiserum for the treatment of pneumonia has decreased somewhat because of the increasing use of rabbit antisera and sulfapyridine. The experiments on antiserum fractionation are a phase of the more general project for the development of technics of ultracentrifugation. It is probable that in many instances mixtures of proteins, not readily separated by ultracentrifugation, can be fractionated by ultracentrifuge methods if there has been previous aggregation of the desired component. Presumably, a semi-specific aggregation may be effected by chemical means under conditions of association peculiar to the protein system being studied. For example, when the ionic concentration of antipneumococcus horse serum is raised above its normal level by the addition of a salt such as ammonium sulfate, the antibody component whose normal molecular weight is in the neighborhood of 900,000 is dissociated into components of much lower molecular weight. Also, the antibody can be reassociated by reducing the salt concentration to roughly one-fourth of its normal value. By this second manipulation, that is, reduction of the ionic concentration of the antiserum, it has been possible to sediment all but a very small portion of the antibody in the ultracentrifuge, even though the antiserum did not readily yield to ultracentrifuge fractionation while in the unaltered state. It is conceivable that protein association and dissociation may be used to aid ultracentrifuge fractionation of protein mixtures of widely different characteristics. Studies on the effects of mild heat treatment, high ionic concentration and low ionic concentration upon the state of aggregation of serum proteins have been undertaken during the past year. This work has been necessary in laying a foundation for more extensive studies.

The second line of research in this field concerns the development, for routine use, of the continuous separation type of air-driven ultracentrifuge. This research is being continued but at present no significant improvement in the design is offered.

The progress report of last year outlined the tests to be made on various steel alloys to be used as rotor steel. Ultracentrifuge rotors of these experimental alloys were to be exploded under centrifugal forces to determine relative tensile strengths under typical operation conditions. These experiments are to be continued in the ultracentrifuge laboratory now being set up in the Foundation's new building.

Electrophoresis.—Electrophoresis as a method for separating electro-chemically dissimilar proteins is exceptionally mild, and as a fractionation procedure it is an aid in obtaining trustworthy products. During this year electrophoresis work has included three classes of study: the characterization of natural and pathological body fluids, the fractionation of protein-bearing fluids to obtain purified samples for further study, and the characterization and study of purified proteins. An extensive study of human ascitic fluid is being carried on as a coöperative project. Other coöperative projects in which electrophoretic analysis has been useful are: a study of the inactivation by heat of purified horse pneumococcus antibody in the presence of casein, and a fractionation of purified scarlet fever toxin. In the case of the toxin from *Streptococcus scarlatinae*, the toxic activity was found to be associated with only one of the three fractions observed in the electrophoretic pattern. Consequently a fractionation by electrophoretic methods yields a purified product heretofore unobtainable. This work is important for a better understanding of scarlet fever immunization and is being carried on in coöperation with the Department of Pathology of the University of Pittsburgh.

Electrophoresis has provided a method for the purification of the proteinase of *Cl. histolyticum;* the pH-mobility relationships of this enzyme are being investigated. It is hoped that the principles of purification developed in this study may be applied more generally to other bacterial enzymes.

Cyclotron.—The cyclotron has been moved into a special wing which has been built for it in the new laboratory at Newark, Delaware, in order that adequate protection may be afforded the Staff. It is housed in the far end of the special wing, about 80 feet from the main building. Two of the walls of this wing and the ceiling over the cyclotron are double, having a three-foot space to be filled with water or a borate solution which will absorb the neutrons generated when the machine is in use. The other two sides of the machine are similarly protected by movable water tanks, making the shielding complete. The control room is situated at some distance from the machine so that the operators will have no occasion to expose themselves to the dangers of irradiation. To decrease the danger of accidental electric shock all high voltage and high frequency elements of the circuits will be completely shielded and safety devices and circuit breakers introduced.

Mass Spectrometer.—It is estimated that about 90 per cent. of the body weight consists of the elements carbon, hydrogen, oxygen, nitrogen and sulfur. Of these, hydrogen, nitrogen and oxygen have no radioactive isotopes suitable for use as indicators in biological tracer work. Their heavy stable isotopes, however, are readily available and can be used as tracer atoms in experiments involving them. For their detection a mass spectrometer has been built by means of which the heavy and light isotopes in any given compound can be separated and their ratios computed. Thus the fate of a compound rich in a heavy isotope can be traced in a biological or chemical

V. 19

system by noting any changes in the ratio of the isotopes in that compound.

Microchemical Analysis.—The primary function of the microchemical group still remains that of service to the research members. Some time, however, was spent on original research problems, directly connected with the analysis of the samples submitted.

Six additional biochemical methods were made available for analytical work. Over 500 total lipid determinations, using Bloor's method, were carried out on blood and liver extracts of rats and mice in connection with the experiments on fat metabolism. Since this method showed certain unavoidable irregularities, the manometric method of Van Slyke was chosen in its place. This procedure gives us not only satisfactory results on fats and lipids, but at the same time promises to be very helpful for many other routine determinations. It is our intention to use this method next for the determination of nitrogen, amino nitrogen and phosphorus.

Experiments verified the findings of Folin that tyrosine and tryptophan are extremely resistant to treatment with very strong alkali. The tyrosine and tryptophan in the breakdown products of proteins were determined within narrow limits.

Rather extended experiments on the determination of purine nitrogen, according to the procedure of Graff and Maculla, are in progress. The results appear to be consistent with various types of material but certain constant losses have been found on checking the procedure with pure guanine. Experiments have shown that this loss with guanine occurs at the stage in which the proteins are removed. Further investigations on purine nitrogen determinations are planned.

The use of the Kofler hot stage for micro-melting points proved valuable in recognizing the ash content of samples connected with the glutamic acid problem. The melting points were found to be inconsistent, the variable factors being the rate of heating, the presence or absence of ash, and the method used. As a routine contribution nearly 150 elementary analyses were made.

The original method of Schoenheimer and Sperry for determining the cholesterol content of serum was modified as follows: (*a*) The clear serum was pipetted into a *cool* mixture of acetone-alcohol for the extraction instead of the recommended hot mixture. (*b*) For the free and total cholesterol determination together, 0.5 cc. of serum were taken for analysis. Larger volumetric flasks were used and the measurements were made easier than in the original method. (*c*) The 0.2 per cent. digitonin solution, prepared according to Schoenheimer and Sperry, was found to be so unstable and so complicated to prepare that various alcohol-water solutions were tested for the efficiency in precipitating the cholesterol and for their stability. Fifty volume per cent. alcohol solutions gave complete precipitation (recovery 99–101 per cent.), and no sediment could be observed even after several months. (*d*) The time interval necessary to saponify the total cholesterol at 37 to 40°C. was increased to 5 hours. (*e*) The amounts of glacial acetic acid and acetic anhydride were reduced to 0.5 cc. and 1.0 cc. respectively, but not the sulfuric acid, since it was inconvenient to measure smaller quantities than 0.1 cc. of concentrated sulfuric acid accurately. For future work it is intended to make up the acid reaction mixture, sulfuric acid and acetic anhydride, and add it to the dissolved cholesterol.

As a part of the coöperative work with the various research groups, a few of the typical problems submitted for solution may be mentioned. Suspensions of bacteria which had been standardized by various other methods were tested for total nitrogen content. The technic consisted of pipetting a known amount of sample into a mixing tube, evaporating the suspending medium, drying *in vacuo* to remove any moisture, and shaking up the residue with copper oxide in the usual manner. The transfer was quantitative, since the values for nitrogen determined by Dumas' method and that by Kjeldahl's procedure agreed very well. The same technic was applied to the estimation of protein in various protein preparations. A modification of this procedure was also used in the analysis of an alcohol-insoluble fraction of urine concentrate which possessed interesting physiological properties.

An old solution of cytochrome *c*, a biological compound containing bound iron, was submitted for comparison with a freshly prepared solution. The investigation showed that free Fe^{++} was present, suggesting that decomposition had taken place upon aging.

The Stereochemical Configuration of Glutamic Acid in Tumor Tissue.—During the past year we have been concerned with an investigation into the nature of the glutamic acid which can be isolated from the proteins of malignant tissues. This work was started soon after Kögl and Erxleben reported, in 1939, that several amino acids, the most important of which was glutamic, obtained by hydrolysis of malignant tissue proteins, were found to be partially racemized, while the same amino acids isolated from normal tissues always possessed the "natural" configuration. On the basis of these observations it was claimed that a clear differentiation between the two types of tissue had been demonstrated.

Realizing that the isolation of glutamic acid by any of the conventional procedures could under no circumstances account for all of the glutamic acid present, we attempted to find a direct method of analysis for the d(−) form in the protein hydrolysate without previous isolation. First investigated was a procedure based on preferential destruction of the natural l(+) form by yeast. The remaining d(−) form could then be determined by the Cohen analytical method. Several strains of yeast were tried, but none was found which eliminated quantitatively one form without attacking the other form. Therefore, this procedure was abandoned.

The next procedure tried was a direct estimation of the d(−) acid by means of d(−) glutamic acid oxidase. Weil-Malherbe had shown that such an enzyme specific for d(−) glutamic acid was present in an extract of lipoid-free brain powder. The enzyme, as reported, was not very active and we were not able to obtain an enzyme active enough to attempt to carry out our plan.

An attempt was made to develop an immunological procedure which could be used to estimate d(−) glutamic acid in tissue hydrolysates. The plan was based on the work of Landsteiner who showed that an antiserum could be prepared which was specific for either optical form of an amino acid. Such an antiserum, specific for d(−) glutamic acid, was prepared. The method, however, was not sufficiently sensitive for small amounts of the d(−) acid, and for this reason could not be applied to tumor tissue hydrolysates which contained at the most only low concentrations of this substance.

Inasmuch as we were unable to find a suitable method for the direct estimation of the unnatural isomer we used the isolation procedures described by Kögl and Erxleben. Adhering as closely as possible to the methods outlined by these investigators we have obtained glutamic acid hydrochloride from ten protein samples representing five malignant tumors and one non-malignant tumor. Since it appeared possible that the "unnatural" acid, if present, might conceivably be unequally distributed in the tumor protein, simple fractionation, i.e., separation of the more-necrotic and less-necrotic portions or separation of soluble and insoluble protein, was carried out in several instances.

Based on the fact that the optical rotation of our isolated samples of glutamic acid hydrochloride indicated a maximum d(−) content of 4.4 per cent., whereas percentages of the order of 15–40 per cent. were reported by Kögl and Erxleben, our work demonstrates that this amino acid, contrary to their claims, is not appreciably racemized when obtained from tumor protein. Our results are in agreement with those of several investigators who have reported equally low percentages of this optical isomer in the acid isolated from both normal and malignant proteins.

Since recent reports have indicated that the yield of the acid should be considered when the extent of racemization is to be determined, it seemed desirable to investigate possible methods for the direct estimation of the total glutamic acid in protein hydrolysates. For this purpose the method described by Cohen involving conversion to succinic acid with subsequent determination of the latter by means of succinoxidase has been applied. Considerable work was done to adapt this method successfully to protein hydrolysates. The results indicate that we have obtained in pure form from 40–70 per cent. of the total glutamic acid present in the tumor hydrolysates. This work represents a new approach to the problem since heretofore no publication in this field has specified the percentage of total glutamic acid isolated. Since our yields are, in general, higher than those of Kögl and Erxleben, it is apparent that they isolated a still smaller proportion of the total acid present in the tumor protein. On the basis of all our results we feel justified in claiming that the glutamic acid of tumor protein is not appreciably racemized.

Discovery of Glycolic Acid Oxidase.—In connection with the investigation concerning the nature of glutamic acid in tumor proteins, it was possible, as has been stated, to apply the manometric method described by Cohen to the direct estimation of this acid in protein hydrolysates. In the course of this work it was found that high values were always obtained whenever rat liver, rather than heart, was used as a source of succinoxidase. Further investigation indicated that serine was the cause of this interference. Since, under the conditions used, serine would be expected to be converted to glycolic acid, the indications were that rat liver, but not heart, contained an enzyme capable of promoting the consumption of oxygen by glycolic acid. This assumption was confirmed when the uptake of oxygen by the pure glycolic acid in the presence of rat liver was measured. This new enzyme was found in rat and in rabbit livers but not in rat kidney, heart nor spleen nor in rabbit kidney, brain nor pancreas. Evidence obtained by plotting oxygen consumption against time showed that the major reaction involves the consumption of one-half mole of oxygen by one mole of glycolic acid. The optimum pH was found to be on the alkaline side.

Plasma Phosphatase.—Investigations were undertaken to find out the functional importance of plasma phosphatase and to throw more light on its relation to metabolic processes. Because of the limited blood supply of the experimental animal, the method used for the estimation of the enzyme activity had to be refined. Using the Linderstrøm-Lang and Holter ultramicro-technique, it was possible to reduce the amount of blood plasma required to less than 1 cmm.

The plasma phosphatase activity was found to be connected with the food resorption mechanism of the animal. The enzyme activity was decreased markedly by fasting and was restored about sixteen hours after feeding was resumed. In order to ascertain which part of the diet is responsible for this reaction the food used was separated into alcohol-ether soluble and insoluble fractions. The ingestion of only the alcohol-ether soluble fraction restored the enzyme activity after fasting. The carbohydrates and the proteins which constitute the insoluble fraction were found to be ineffective. Since the alcohol-ether soluble fraction consists of a mixture of lipids, investigations were conducted to determine which part of the lipid fraction is responsible for the mobilization of the plasma phosphatase activity. Experiments, carried out with chemically pure constituents of lipids, have shown that an increase in the low plasma phosphatase activity produced by fasting resulted from the ingestion of only certain types of unsaturated fatty acids, in which a certain molecular magnitude, the double bond in the carbon chain, and the free carboxyl group are essential.

The relation between the plasma phosphatase activity and cancerous and normal growth was investigated. Experiments in which the plasma enzyme activity was measured parallel to the tumor growth did not show any definite changes. However, when the normal growth of the rat was followed it was found that the plasma phosphatase activity of the rat embryo was very low, remaining at the same level until the age of about three weeks, after which time the enzyme activity rose rapidly.

Definite variations from the normal plasma phosphatase activity were observed in pregnant rats. A marked drop in the enzyme level was noted about 5 days before parturition, after which the enzyme activity rose considerably above the original normal level, dropping again to the normal level when the lactation period was over. The high plasma phosphatase activity during lactation may be connected with the increased milk-fat production of the rat.

Present experiments indicate that the increased plasma phosphatase activity due to the ingestion of unsaturated fatty acids is closely linked with the phospholipid metabolism of the animal.

Our chief aim is to clarify the mechanism of fat transportation from the intestinal mucosa to the various organs where the fats are further utilized, and to investigate the cases where the utilization of fat is disturbed, thus leading to pathological fat depositions.

A Fraction of Human Urine Causing Fetus Resorption in Animals.—A water soluble fraction has been prepared from the urine of cancer patients and also from the urine of a healthy person, which when administered intravenously to pregnant rats and mice caused fetus resorption. The fraction yielded negative results in tests for protein but a positive result in the Molisch test for carbohydrate. The active principle did not pass through dialyzing membranes but was rendered inactive by autoclaving for one hour at twenty pounds steam pressure. The fraction was found to be toxic to pregnant mice and rats, causing stupor and marked loss in weight and bleeding followed by fetus resorption and eventual recovery of the animals.

Attempts to isolate and identify the active principle have so far been unsuccessful. These efforts are being continued.

Effect of Tumor Implants on Estrous Cycle in Douredoure Rats.—The subcutaneous implantation of the Walker carcinoma or the Philadelphia No. 1 sarcoma into young but sexually mature rats of the Douredoure strain was found not to influence the frequency, duration, or nature of the estrous cycle until the tumors became so large and necrotic as to cause severe toxic symptoms. These results are not in agreement with the reports published by some other workers. It is suggested that the reactions to tumor implantation may not be the same in all the strains of rats and that possibly the tumor used and the method of implantation may be factors influencing the ultimate results.

Effect of alpha-Estradiol Benzoate on Skeletal Development of Immature Rats.—Young rats of the Douredoure strain, varying in age from three days to eighteen days and weighing from eight to twenty grams at the beginning of the experiment were used. alpha-Estradiol benzoate was injected at intervals for experimental periods varying from seven to fifty days. The number of doses varied from three to fourteen and the total amount of the hormone administered from fifty to two hundred fifty gamma. Under these experimental conditions no demonstrable effects were produced on the skeletal development, although marked effects were produced on the thymus and the uterus.

A Fraction from E. coli Which Causes Diarrhea in Rats.—An aqueous solution of the alcohol precipitate of *E. coli* when filtered free of organisms and thoroughly dialyzed has been found to be toxic to rats when administered intravenously.

In sub-lethal doses the fraction caused diarrhea and loss in weight.

The fraction yielded negative results in tests for protein but gave positive results in the Molisch test for carbohydrate. Additional attempts to purify and identify the active principle are planned.

Atheroma.—Confirming work reported in the literature, atheromatous lesions have been produced in the coronary arteries and aorta of rats by feeding large amounts of viosterol. An experiment is now in progress in which rats are being exposed daily to ultraviolet light in order to determine whether or not atheromatous lesions may result. Atheroma is usually regarded as a disease of the aging period of life, but it may appear at an early age, and during the World War was found in large numbers of healthy young men.

Hepatoma in Rats.—Cancer of the liver has been produced in rats, in confirmation of the work of previous investigators, by feeding a diet containing the dye "butter yellow." Experiments are now in progress to determine whether the addition of spleen or of an alcohol-ether extract of spleen to the hepatoma-producing-diet will prevent the development of the liver cancers. The experiments are now in the preliminary stages and the results are not yet ready for presentation.

The Passage of Bacteria from the Peritoneal Cavity Into the Blood Stream of Rats.—*E. coli*, *Staph. aureus*, *Eberth typhi* and *B. subtilis*, when introduced into the peritoneal cavity of rats, were found to enter the blood stream in the order named, with *E. coli* passing in the most rapidly. The difference in size of the bacteria does not offer a satisfactory explanation for the different rates of passage in the body; neither does the possession of natural agglutinins for these organims by the animals, since none were found. In an attempt to explain the differences in the rates of passage the relative chemical staining charge of the organisms was determined. A parallelism between the chemical staining charge and rates of passage within the animal was found.

Nucleic Acid.—The importance of nucleic acid in living cells is a well established fact, although the exact nature of the role that it plays in cell metabolism is still a subject for further investigation. In recent years, many workers have studied its occurrence in cells of various types by purely physical methods. In this work advantage has been taken of the fact that nucleic acid absorbs ultraviolet light at about 2600 A.U. very strongly, while other components usually present in cells are, by comparison, weakly absorbing in that region. The absorption, therefore, of ultraviolet light at about 2600 A.U. is a rough measure of the nucleic acid content of cellular material.

In accordance with this principle, studies of the absorption of ultraviolet light of several bacteria, *B. subtilis, Staph. aureus, Eberth. typhi,* and *E. coli,* have been undertaken, in order to correlate the nucleic acid content with their staining characteristics. To keep conditions comparable the absorption was determined on bacteria which had been previously prepared for staining rather than on living bacteria. The bacteria were pressed into a thin layer between two quartz plates, and the thickness of the film measured by interferometric methods. A similar film of glycerine was prepared as a control. The light transmitted by the bacteria and by the glycerine was measured alternately and the absorption coefficient calculated. The absorption was determined between the wave lengths of 3000 and 2300 A.U. The results showed marked differences in the absorption of these bacteria as taken under the conditions described.

The determination of the stain uptake of these four organisms has also been studied. The amount of dye taken up by three of them was found to be in direct proportion to their relative nucleic acid content while the amount of dye taken up by the fourth organism was dependent upon its mucoprotein coating. The dye uptake by the method used was found to be independent of cataphoretic charge.

The determination of nucleic acid in tissue slices is being studied. Caspersson and others have shown that the nucleic acid content of the nucleus of a cell increases during mitosis. Our present study was designed to determine the nucleic acid content of the cytoplasm of areas of active growth in contrast with areas of more mature tissue, particularly of cancer tissues. In this method a quartz microscope, having all quartz optical parts, is illuminated with monochromatic light. The slide carrying the section to be studied is placed on the stage of the microscope and a projection image formed on a glass diaphragm, in which a small hole has been bored. This can be viewed by visible light and moved until the image of the desired portion of the cell is over the hole. Ultraviolet light is then used to illuminate the microscope. Only the light from that part of the image over the hole in the glass diaphragm will be transmitted, since the glass is opaque to wave lengths around 2600 A.U. In this way the light transmitted by any given part of the cell can be separated and measured, and the absorption of that portion of the cell studied.

Apparatus has been assembled for the study by staining methods of the relative nucleic acid contents of mitotic and resting nuclei. This consists of a special micromanipulator fitted with a turbine type cutting tool, a micro-injection assembly and a 15 cu. mm. microcolorimeter. The apparatus will be used to determine quantitatively the amount of dye taken up by the various nuclei in tumor tissue which dye uptake is a measure of relative nucleic acid content.

Numerous human and animal tumor tissues have been stained with the differential pH stain and are being studied to determine the relative nucleic acid content of the different types of nuclei.

The ribose nucleic acid content of tumor nucleoproteins and tumor tissue is being investigated. Results so far obtained indicate a high ribose content for both the nucleoproteins and the tissue.

Substance Isolated from Soil Bacteria.—Several microorganisms which were isolated from soil around Philadelphia have been found to excrete a substance (or substances) that displayed very interesting biochemical behavior. It was found that the broth in which these organisms, normal inhabitants of the soil, had been grown contained a substance which in minute amounts prevented certain pathogenic bacteria from forming a "capsule." This capsule acts as a protective coat around the bacterium, and prevents the phagocytes in the blood of higher animals from engulfing it. This phenomenon of the inhibition of encapsulation of pathogenic bacteria was studied mainly on the so-called Friedländer's bacterium, the causative agent of bronchial pneumonia.

From a broth culture of the soil bacteria we succeeded, after extensive investigation, in preparing an almost colorless powder, in which practically all of the activity present in the broth was concentrated. This powder was soluble in alcohol, acetone, glacial acetic acid, dioxane, and when a solution of the powder in any of these solvents was mixed with water a slightly opaque colloidal solution resulted. A small amount of the colloidal solution, containing not more than a few thousandths of one milligram of the powder, when added to the ordinary broth, made this broth definitely unsuitable for the encapsulation of the Friedländer's bacterium, but did not interfere with the normal growth of the bacterium.

The alcohol soluble powder appeared to be an unusual polypeptide with a high content of tryptophan and tyrosine. When the substance was tested to see whether it would also prevent pneumococci from forming capsules, it was found that not only were the pneumococci prevented from forming capsules but also that these organisms were destroyed by minute amounts of the same powder.

Not only pneumococci were destroyed by the excretion product of the soil bacillus, but also a large number of other disease-producing bacteria such as the streptococci, which cause diseases such as erysipelas, blood-poisoning, rheumatic fever, staphylococci which cause infections such as boils and furuncles, the Welch bacillus which causes gas-gangrene and the anthrax bacillus which causes wool-sorter's disease. All these pathogenic organisms belonging to the great group of "Gram-positive" organisms were killed or made inactive by minute amounts of this white powder.

Meanwhile, work has been in progress to purify the bacterial extract in order to eliminate the fraction responsible for its too toxic properties with the hope of making it suitable for internal use. One highly active fraction has been obtained in crystalline form. This fraction crystallized in the form of lens-shaped platelets and colorless needles containing 62.7 per cent. carbon, 7.6 per cent. hydrogen, and 14.9 per cent. nitrogen. It did not inhibit encapsulation of Friedländer's bacterium nor cause hemolysis of red blood cells, but was highly bactericidal for Gram-positive organisms. Although the toxicity of this material was less than that of the crude extract, it was too toxic to be injected into the animal body with impunity.

The bactericidal effect of this agent *in vitro* suggested the possibility of its use for the treatment of diseases. Indeed, it was found that animals injected with many times the lethal doses of pneumococci, streptococci or anthrax could be saved by injections of a solution of this substance. Unfortunately, however, the substance appeared to be too toxic to be used internally. On the other hand, it could be used externally without any disadvantages to the human body. The application of this material in the treatment of infected wounds is reported under clinical investigations. Almost a hundred grams of this material have been prepared from more than a thousand liters of culture medium.

The isolation of the active fractions from cultures of soil bacteria has been based, in general, on two properties of this material: the solubility in ethyl alcohol and the insolubility in petroleum ether and benzene, and the fact that it is precipitated from alcohol solution by the addition of a solution of sodium chloride. Using this method of isolation the material has been prepared from a number of forty liter lots of culture medium and is being stored in anticipation of any future demand.

Other strains of soil bacteria which excrete similar bactericidal substances have also been found and now work is under way to isolate these substances in pure state, with the hope that eventually a substance may be found that lacks toxic properties for higher animals but is still bactericidal for pathogenic bacteria. The existence of such a substance becomes likely since it is apparently possible to isolate from this source substances which are highly toxic for one form of life but not at all for other forms of life, a property which is rarely encountered in the field of bactericidal substances.

From soil and sewage, we have isolated at least a dozen strains of soil bacteria, belonging to several genera, all excreting bactericidal substances. From one of these strains the active principle has been isolated. In contrast to the substance described above, this substance contains sulfur and phosphorus and is soluble in dilute sodium hydroxide. Its bactericidal potency is at least as great as that of the first substance, and it is also bactericidal for certain species of the Gram-negative bacteria such as *Klebsiella rhinoschleromatis*, an organism responsible for certain chronic inflammation of the nose. It is also active against certain species of the acid-fast bacteria, the group to which the tubercle bacillus belongs.

In view of the fact that almost all previous work on bacterial antagonism has been done on bacteria freshly isolated from soil, an investigation of antagonism among the well-known bacteria has been undertaken. This study will include the determination of antagonistic bacteria, and the investigation of the substances which are responsible for the antagonism. A number of species have been found to inhibit other organisms such as *Bacillus anthracis*, which appears to be the most readily inhibited.

Thus, the discovery of a substance inhibiting the encapsulation of Friedländer's bacterium has opened a new field for research, the exploration of which may yield valuable products for combatting bacterial diseases.

Clinical Studies.—The bactericidal agent isolated from soil bacteria has been used for treating external infections in man. The material has been used in the form of wet dressings saturated with a colloidal suspension of the crude material in varying strengths from twenty to one hundred milligrams per liter, and as an irrigation solution with the drip method. Nearly fifty cases have been treated with this promising antiseptic. In addition to a rapid combatting of the infection, the preparation appears to have another effect, namely, that of causing the wounds to heal quickly. Our brief experience indicates that this material is safe to use on external lesions, that it quickly arrests infections caused by Gram-positive organisms, and that it stimulates wound healing.

Studies on Cancer Origin.—This is a report of a three and one-half year investigation the aim of which was to confirm, deny or clarify the long-standing contention of the bacterial etiology of cancer. The theories of the bacterial origin of cancer have been reviewed and carefully considered. Nearly 10,000 cultures were performed in an effort to confirm or deny the hypothesis that cancer is due to a microscopically visible germ. Various microörganisms resembling those reported by different writers were found occasionally in cancer tissues, cancer blood and cancer fluids. No specific "germ" has been consistently found in our examinations. This research has dealt mainly with microscopically visible organisms and but little with viruses. Neither cancers nor tumors were produced in the numerous rats which were injected with germs derived from tumors nor in rats which were injected with an extract of infected wheat. If cancer is due to a microscopically visible germ, we have not been able to demonstrate it with cultural materials and microscopic apparatus available at the present time.

Leukemia.—We have been studying leukemia for several years and are more specially interested in it now because of the newer aspects of induced or artificial radiation. In past time, the only treatment for this incurable disease was the extensive use of X-rays which merely prolonged life.

In the two years past, we have had some interesting results with the newer or induced radioactive substances. Now that the cyclotron is in position in our new laboratories at Newark, Delaware, with the animal rooms in immediate proximity to it, we shall continue the study of these new forces on this disease.

However, as is always the case, to do this requires not only the new force, but a very definite background of knowledge as to the subject to which it is applied, particularly in biological material whether animal or human. For this reason, we have been studying transmissible transplanted and hereditary leukemia in mice in all the ramifications so that we may be prepared for the study of induced radioactive substances upon this disease. This involves breeding a special colony of mice, a knowledge of their metabolism through their life history, including their blood changes, and the perfection of physical methods (Geiger counters, etc.) for the recognition and measurement of the radiation in the animal body: all this besides the complicated production of the radioactive material by the cyclotron and its transfer into chemical substances which may be ingested by or injected into the animals. So that a lot of detail goes before the final experimental results as is always the case in biochemical or biological experimentation, bringing together various phases of apparently unrelated research.

Library.—The library has grown from a helpful assistant to an absolute necessity in the research laboratory. Several years ago it was considered coincidental when the same contribution to science was developed independently in two or more laboratories. Today it is considered wasteful duplication. The research worker depends upon the literature of today and of yesterday to be sure that the same investigations are not being carried on elsewhere or have not been carried out years ago.

One of the most effective means of keeping scientific literature at the disposal of the investigator is our reprint collection. These reprints, which constitute one of the largest classified and catalogued collections in the world, have now passed the 25,000 mark. The subject files are being reclassified and more minutely subdivided to make the literature on any subject more readily and quickly accessible.

Our subscription list of journals including over a hundred periodicals is carefully checked from time to time to assure our receiving the most recently published material in the fields of immediate interest to our staff. Older series and back numbers which are invaluable in literature check-ups and bibliographical search are added from year to year.

Reference and text-books, annual reviews and recent advances are kept up to date for the convenience of the research workers.

The translation service of the library is at the disposal of our staff. Bibliographical material is assembled and obscure literature references traced and obtained.

Publication.—During the research year September 1939 to September 1940, 18 publications appeared in various scientific journals; 9 additional articles were in press at the close of the year. The "Notes from the Biochemical Research Foundation," which appeared each month in the JOURNAL OF THE FRANKLIN INSTITUTE, consisted of 9 original articles, 6 reports of lectures or seminars and 18 reviews of recently published papers by members of the Staff.

Reprints of the "Notes" and of the publications by our investigators have been added to the laboratory files. Our publications now number 173; the List of Publications is available on request.

Volume V of "Reports of the Biochemical Research Foundation," consisting of publications for 1938–1939, appeared in January 1940.

Our work in this year has been somewhat hampered by the progress of moving to our new laboratories at Newark, Delaware. Plans were made long ahead so that there should be as little disturbance as possible to the progress of the research. Of course there will be, in spite of all efforts, considerable upset. In such an integrated and coöperative group as ours the disturbance is greater than in a group of prima donna type of workers. It is not merely moving the individual staff from one place to another, but the transplanting of a whole group with all their complicated apparatus into a new place.

If there were only a magic carpet to take the whole and set it down in the new place, it would indeed be wonderful. But upset in research will occur, not only in the leave-taking with all the preliminary packing and such disturbance, but in the new place with the distribution and settlement of people and material there. Then too research workers need some time to get accustomed and to feel at home in new quarters.

For all this we have tried to make preparations since the beginning of the year so as to diminish disturbance. Any such disconnection will, however, be much more than compensated in a short time by the convenience and arrangement of having, at last, our group of scientists all under one roof, each in his own place, all in a laboratory the plans for which were studied for several years from the point of view of the coöperation and coördination of research workers of various phases of chemistry, physics, enzymology, biology, cytology and medicine, so that a united effort may be made along one front for the advancement of science and the benefit of mankind.

THE VELOCITY OF SOUND.

BY

R. C. COLWELL, A. W. FRIEND AND L. H. GIBSON,

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ABSTRACT.

A new method for measuring the velocity of sound over short distances has been devised in which sixty pulses per second cause a sinusoidal curve to appear upon an oscilloscopic screen. As the receiving microphone is moved away from the sound oscillator, the crest of the sine curve moves across the oscilloscope, completing the circle in one-sixtieth of a second. The actual velocity of the sound is easily calculated after the distance moved by the microphone has been measured.

Application of the probability laws and the error curve shows that the method is very accurate, providing the alternating current maintains itself invariably at sixty cycles per second. The average of twelve hundred measurements gives 331.364 ± 0.043 meters per second at zero degrees centigrade.

The velocity of sound in free air has been measured by many different methods over long distances, but with modern electrical devices it may be measured over short distances in the laboratory. In order to avoid echo effects, the walls must be covered with sound absorbing material, or the equipment enclosed in a box similarly lined.

The apparatus used in this method consists of an electron tube connected in the circuit in such a way that sixty short impulses per second are given to the loud speaker. This pulse device is very similar to other apparatus which has been used in ionospheric measurements.[1] The chief difference lies in the fact that the condenser discharges pass through a loud speaker instead of a resistor. The timing of the impulses is very uniform, because the trigger device is exactly synchronized with the sixty cycle power line.

The sound pulses are picked up by a microphone which converts them into electrical currents. After amplification, they are observed on the screen of a cathode ray oscilloscope.

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[1] R. C. Colwell, A. W. Friend and N. I. Hall, *R. S. I.*, **7**, 420 (1934); R. C. Colwell and A. W. Friend, *Phys. Rev.*, **50**, 632 (1936); R. C. Colwell, A. W. Friend and D. A. McGraw, J. Fr. Inst., **225**, 579 (1938).

The microphone is movable back and forth along a graduated rod about six meters long.

The measurements were made in the following manner. With the current turned on, the microphone was moved close to the loud speaker, then adjusted until the peak of the impulse was on the index line. This was a vertical line in the center of the oscilloscope screen. The position was marked and the microphone moved along the graduated rod until the crest of the sine wave formed by the sound from the speaker was again on the index line. The distance between the two positions of the microphone gave the distance that a wave traveled in one-sixtieth of a second, or the distance the sound traveled during one cycle. Since the pulse generator gave out sixty short pulses each second, the velocity of sound at the temperature of the room was found by multiplying the distance traveled in one cycle by sixty.

The readings were grouped in tens and the velocity of sound at standard conditions was found for each group by the formula $V_t = V_0\sqrt{1 + t/273}$. Table I gives an example

TABLE I.

Distance.	Distance.	Distance.	Distance.
582.6 cm.	585.6 cm.	576.7 cm.	581.7 cm.
583.7	584.2	582.1	580.4
582.8	583.0	580.6	581.1
584.1	585.4	580.9	578.0
583.9	584.4	580.4	579.4
582.7	584.6	580.3	582.2
584.3	586.5	580.1	580.5
586.7	583.0	581.6	578.3
584.1	583.9	580.5	579.8
583.4	585.4	579.0	578.6
Av. 583.83	584.60	580.22	580.00
T 33.4°C.	33.4°C.	30.0°C.	29.6°C.
V_t 350.30 mtr./sec.	350.76 mtr./sec.	348.13 mtr./sec.	348.00 mtr./sec.
V_0 330.66	331.09	330.45	330.55

of the results obtained with a time interval of one-sixtieth of a second.

Twelve hundred measurements were taken and the average was found to be 331.364 meters per second, which agrees very well with the results from other methods. Table II shows

TABLE II.

Velocity of Sound in Meters/Sec.					
330.95	331.32	330.86	331.36	330.92	331.62
331.07	331.24	331.02	330.62	331.95	331.36
331.10	331.18	331.14	332.03	332.29	331.71
331.62	331.09	331.29	330.94	331.54	331.77
330.77	330.98	330.87	331.73	331.53	330.93
332.14	331.19	330.45	330.84	330.86	330.79
331.11	330.89	331.18	331.18	330.66	331.09
330.45	330.55	331.36	330.77	331.10	330.50
330.79	330.64	331.70	331.90	331.72	331.83
331.99	331.99	332.37	332.29	332.03	332.23
332.33	332.47	332.25	332.44	332.25	331.82
332.27	331.76	332.06	332.15	331.93	333.02
331.38	332.77	332.79	331.41	331.58	331.25
331.52	330.66	331.78	331.42	332.38	330.20
330.41	330.08	330.81	330.99	330.76	330.27
330.85	331.17	330.54	331.24	331.41	331.27
331.83	331.36	331.15	331.19	331.21	330.84
331.65	331.67	331.35	331.49	330.95	330.80
331.00	330.89	331.00	330.77	330.82	331.65
331.50	331.65	331.48	331.56	331.38	331.42

Average = 331.364 meters/sec.

the values obtained for the velocity of sound under standard conditions.

The probable error of the result was found in the following manner. The deviations of each group from the arithmetic mean of V_0 were found and added. The sum of the deviations was found to be 56.57 meters/sec. Substitution in the formula for the probable error of the mean gave:

$$\text{P.E.} = \pm\, 0.845\left[\frac{\sum\delta}{n\sqrt{n-1}}\right].$$

$\sum\delta$ = summation of deviations.

n = number of groups.

$$\text{P.E.} = \pm\, 0.845\left[\frac{56.57}{120\sqrt{119}}\right]$$

$$= \pm\, 0.036 \text{ meters per second.}$$

Therefore $V_0 = 331.364 \pm 0.036$ meters per second.

To determine whether the data obtained followed the normal curve the method of moments was used. A class interval of 0.2 meter/sec. was the separation. All values of V_0 were grouped in these intervals. This gave fifteen class intervals ranging from 330.0 meters/sec. to 333.0 meters/sec. which is represented by Z in Table III:

TABLE III.

	n/m.	δ.	δZ.	$\delta^2 Z$.	$\delta^3 Z$.	$\delta^4 Z$.
Z_1	0.0167	1.27	0.0212	0.0269	0.0342	0.0434
Z_2	0.0167	0.97	0.0162	0.0157	0.0152	0.0148
Z_3	0.0333	0.77	0.0256	0.0197	0.0152	0.0117
Z_4	0.0833	0.57	0.475	0.0271	0.0154	0.0088
Z_5	0.1583	0.37	0.0586	0.0217	0.0080	0.0029
Z_6	0.1083	0.17	0.0184	0.0031	0.0005	0.0000
Z_7	0.1167	0.03	0.0035	0.0001	0.0000	0.0000
Z_8	0.1250	0.23	0.0218	0.0066	0.0015	0.0004
Z_9	0.1000	0.43	0.0430	0.0185	0.0080	0.0034
Z_{10}	0.0750	0.63	0.0473	0.0298	0.0187	0.0118
Z_{11}	0.0415	0.83	0.0344	0.0286	0.0237	0.0197
Z_{12}	0.0667	1.03	0.0687	0.0708	0.0728	0.0750
Z_{13}	0.0250	1.23	0.0308	0.0378	0.0465	0.0572
Z_{14}	0.0167	1.43	0.0239	0.0341	0.0488	0.0698
Z_{15}	0.0083	1.63	0.0135	0.0220	0.0359	0.0585
				0.3625	0.1674	0.3774

$$\frac{n}{m} = \frac{\text{number of readings in class interval}}{\text{total number of readings}}.$$

δ = deviation of class interval from arithmetic mean.

δZ, $\delta^2 Z$, $\delta^3 Z$, $\delta^4 Z$ = moments M_1, M_2, M_3, M_4.

By the use of the beta diagram [2] the type of curve nearest the data was found. The values of beta were found from the formulas:

$$\beta_1 = \frac{(M_3)^2}{(M_2)^3}, \qquad \beta_2 = \frac{(M_4)}{(M_2)^2}.$$

The values are given in Table IV.

From the beta diagram it was found that the data were very near the normal curve: $y = y_0e^{-x^2/A}$. The constants may be calculated from the formula:

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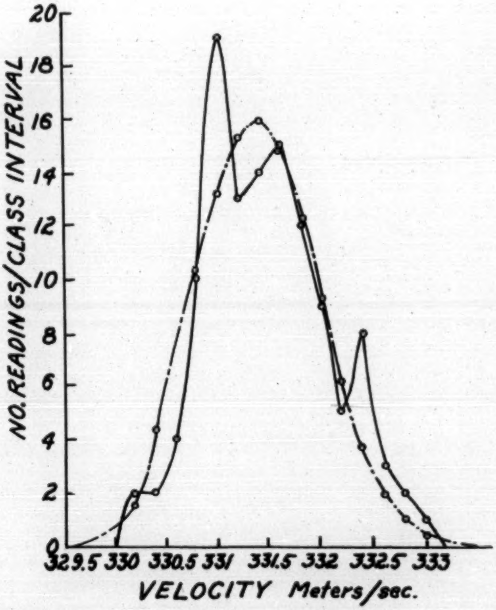
[2] "An Outline of Probability and Its Uses," Maurice C. Holmes, page 87, Edwards Brothers, 1936.

$$A = 2(M_2) \quad \text{and} \quad y_0 = \frac{Z}{\sqrt{2\pi M_2}}.$$

The values of these are shown in Table IV:

FIG. 1.



To determine the fit of the curve the chi-square test was used. In Table V, y' = the values calculated for certain values of x, has to be multiplied by 120 since there are 120 values of V_0. Then $y - 120y'$ = the deviation of $120y'$ from the y value of each value of x. The y value is obtained from the curve (Fig. 1). $\frac{}{(y - 120y')^2}$ = value of x for each interval.

TABLE IV.

$$\beta_1 = \frac{(0.1674)^2}{(0.3625)^3} = 0.5883 \qquad y_0 = \frac{0.2}{\sqrt{2\pi(0.3625)}} = 0.1325$$

$$\beta_2 = \frac{(0.3774)}{(0.3625)^2} = 2.872 \qquad \frac{x^2}{A} = \frac{x^2}{0.725} = 1.379x^2$$

$$A = 2(0.3625) = 0.725 \qquad y' = 0.1325e^{-1.379x^2} \qquad (1)$$

It is necessary to multiply the value of y' by 120 as there are 120 values of V_0. The different values of x in equation (1) are the deviations of the class intervals from the arithmetic mean V_0.

Figure 1 shows the curve obtained from the data and the normal curve which was calculated.

TABLE V.

y.	y'.	$120y'$.	$y - 120y'$.	$\frac{(y - 120y')^2}{y}$.
2	0.0143	1.72	0.28	0.0392
2	0.0362	4.35	−2.35	2.7613
4	0.0586	7.03	−3.03	2.2952
10	0.0847	10.17	−0.17	0.0029
19	0.1098	13.17	5.83	1.7889
13	0.1273	15.28	−2.28	0.3999
14	0.1323	15.88	−1.88	0.2524
15	0.1243	14.92	0.08	0.0004
12	0.1027	12.33	−0.33	0.0091
9	0.0767	9.21	−0.21	0.0049
5	0.0514	6.16	−1.16	0.2691
8	0.0308	3.69	4.31	2.3220
3	0.0165	1.98	1.02	0.3468
2	0.0079	0.95	1.05	0.5513
1	0.0034	0.41	0.59	0.3481
				$11.3915 = x^2$
				$p = 0.496$

From the value of x^2, the fit of the curve was found to be 0.496 in the chi-square tables. The n used in the chi-square table was the number of class intervals less the number of parameters in the equation of the calculated curve. This value for p represents the probability that another set of data taken in the same way would fit the normal curve just as well as the present data. It follows that this new method of measuring sound velocities will give very accurate results even over short distances.

THE SEQUENCE ILLUSION.

BY

RONALD L. IVES.

ABSTRACT.

When all lights of a linear series are illuminated simultaneously, they appear, to a casual observer, to be illuminated in sequence, that nearest the observer, all other conditions being substantially the same, being perceived first. This "sequence illusion" is explained by application of well-known physical and physiological principles, and its importance as a factor in certain observations of natural phenomena is discussed, with a practical example.

DESCRIPTION OF ILLUSION.

Simple Case.

When the lamps of a linear series, such as the overhead lighting system of a long boulevard, are illuminated simultaneously, many casual observers will report that they went on in sequence, the nearest light first, followed by the others in inverse order of their distance. This is the simplest, and most-often-noted, example of an illusion here referred to as the "sequence illusion."

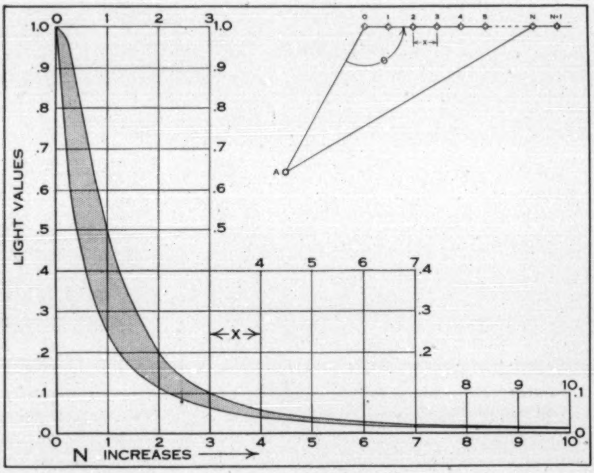
If the lights are numbered away from the observer, with *o* nearest, *1* next, and so on (Fig. 1, inset, upper right), the reported order of illumination will be $o - 1 - 2 \cdots N - N + 1$, etc., *provided all the lamps are of the same wattage.*

A majority of observers report that the interval between the illuminations of lights *o* and *1* is much greater than that between those of a more distant pair, N and $N + 1$, and in general terms describe a "wave of illumination" the velocity of which increases with distance from the observer.

More Involved Case.

When all lights of the series are not of the same wattage, as when those at intersections with a boulevard are more powerful than those between, many observers will report that the intersection lights were illuminated before those between, and will opine that the intersection lights are on a separate circuit which was turned on first!

FIG. 1.



In this case, the sequence effect is usually reported for the brighter series of lights only. One report under these conditions, however, is of considerable interest, and will be here described in a slightly simplified form. On a long boulevard, the lights numbered *0*, *10*, *20*, etc., were several times as strong as those intervening. The reported sequence of illumination was as follows: *0—10—20—1—2—3* · · · *8—9—30*—(*11* to *19* simultaneously)—*40*—"all the rest."

When lights having unequal wattages and complex arrangements, as those at "cloverleaf" and "pretzel" highway intersections, are turned on simultaneously, various illusory effects are noted, but these, in general, are so complex as to confuse the observer.

Conditions for Maximum Effect.

The sequence illusion is most effective when noted casually, by a slightly tired observer, whose eyes are in transition from "day" to "night" vision. It is least effective, and in many instances cannot be detected at all, when the observer is untired, alert, and expects the illusion to occur. Several dozen rough tests indicate that the best observers are those having low I.Q.s and rather limited backgrounds: the worst are highly intelligent people used to working with high-speed machinery.

ANALYSIS OF ILLUSION.

General Discussion.

With the sequence illusion, the reported phenomena consistently differ from the actual occurrences. Standard physical calculations reveal the actual intensities of the stimuli reaching the observer's eye. Illusory features, revealed by the discrepancy between actual and reported happenings, are explained by the physiological properties of the human eye. It seems probable, although proof is lacking, that animals other than *Homo sapiens* are also subject to this illusion.

Physical Features.

From the laws of radiation it is known that the intensity of the light reaching the inner surface of a sphere from a centrally-located point source can be calculated from the formula:

$$I = \frac{k}{S^2},$$

where I = light value,
k = a constant,
S = radius of sphere.

This is a statement of the well-known "inverse square law."

From simple trigonometry, the length of a line $\overline{AN}$ in an oblique triangle AON (Fig. 1, insert, upper right) can be found from the formula:

$$\overline{AN} = \sqrt{\overline{AO}^2 + \overline{ON}^2 - 2\,\overline{AO}\;\overline{ON}\cos\theta},$$

where $\overline{AO}$ = length of one side,
$\overline{ON}$ = length of second side,
$\overline{AN}$ = length of third side,
θ = angle AON.

This is a statement of the *law of cosines*.

These two formulæ can be conveniently combined to facilitate computation, the result being the formula

$$I = \frac{k}{\overline{AO}^2 + \overline{NX}^2 - 2\,\overline{AO}\,\overline{NX}\cos\theta}.$$

For the calculation of an illustrative case, let it be assumed that the intensity of the light received at A from O is unity, and that $\overline{OA} = X = 1$. It should also be apparent that the distance from O to any lamp N is NX. From the simplified formula,

$$I = \frac{1}{1 + N^2 - 2N\cos\theta},$$

the curves constituting the boundaries of the shaded area in Fig. 1 were calculated. In this figure, the limiting values of θ are 90° (upper curve) and 180° (lower curve). Intermediate values of θ give similar curves, all falling within the shaded area in the figure. For rigorous mathematical correctness, a discontinuity at $\theta = 180°$ must be recognized.

These curves show plainly that regardless of the position of the observer (except for $\theta = 180°$) the effective intensity of the light reaching his eye from a given lamp is inversely proportional to the distance of the light from him, all other factors being the same. It is also notable that the ratios of the intensities of proximal lights, such as o and 1, are greater than those of more distant sequent pairs, such as N and $N + 1$.

Physiological Factors.

Pioneer investigations of the relation of reaction time to strength of stimulus, done by Froeberg in 1907,[1] disclose that reaction time is an inverse function of stimulus intensity. More recent work, summarized by Woodworth,[2] confirms Froeberg's findings, but indicates that beyond certain maximum intensities of stimulus the generalizations suggested by Froeburg are no longer valid.

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[1] Froeberg, Sven (1907), "The Relation Between the Magnitude of Stimulus and the Time of Reaction," *Archives of Psychology*, 1, No. 8, pp. 8–17.

[2] Woodworth, R. S. (1938), "Experimental Psychology," New York, pp. 317–320.

If it is assumed that perception of a stimulus is in itself a reaction to that stimulus, it may be stated that (within reasonable limits) the duration of "perceptional lag" is an inverse function of the effective strength of the stimulus.

In mathematical terms it may be stated that

$$L = \phi \frac{c}{I},$$

where ϕ indicates "is a function of,"
L = perceptional lag,
c = a constant,
I = effective intensity of stimulus.

Explanation of Illusion.

Combining the intensity formula $I = k/S^2$ with the lag formula given just above, and applying it to the case of multiple stimuli of equal absolute intensities and unequal distances from the perceptor, the order of perception may be determined from

$$L_0 = \phi\, CS_0^2,$$
$$L_1 = \phi\, CS_1^2,$$
$$L_2 = \phi\, CS_2^2,$$
etc.

where L_0, L_1, L_2, are various lags for stimuli numbered to correspond with the subscripts,
S_0, S_1, S_2, are the distances between perceptor and stimuli with numbers corresponding to the subscripts.

This method of treatment explains quite plainly the existence of the simple sequence illusion, and calculated orders of perception agree exactly with those observed and reported.

Consideration of the reported decrease in the perceived interval between the illuminations of consecutively placed lights as the distances of the pairs from the observer increases suggests that perceptional lag is a logarithmic or quasi-logarithmic function of stimulus intensity.

Comparable formulæ, derived from the basic formula,

$$L = \phi\, C \frac{S^2}{F},$$

where F = absolute intensity of stimulus (i.e., candlepower of light)

can be used to explain many of the reported phenomena connected with the more involved sequence illusions. The assumption that the perceptional lag is a logarithmic function of effective stimulus intensity is not entirely satisfactory in this case, and no definition of the function, ϕ, other than "apparently quasilogarithmic" seems justified by the limited data available.

Factors Not Considered.

Although the physical and physiological factors considered above give a plausible and apparently satisfactory explanation of the sequence illusion, and suggest that it follows some approximate law, roughly paralleling Fechner's law, the explanation is patently a first approximation, in which a number of factors, some negligible, and others of some probable importance, have not been considered.

For the purposes of this investigation, the velocity of light can be assumed infinite. Electrical lags in standard incandescent lighting systems, whether series or parallel, can be taken as zero.

Differences in the sensitivity of the various parts of the visual field are known to exist, and should have some effect on the illusion for every value of θ except $\theta = 180°$ (at which value the nearest light effectively conceals all the others, and a sequence illusion is impossible!). This factor, not considered here, may be of considerable importance in a more detailed evaluation of illusions of this general type.

Various experiments indicate that no two observers perceive exactly the same illusion, that there are pronounced day-to-day, and perhaps hour-to-hour variations with a single observer, and that as soon as an observer becomes aware that he is reporting some sort of an illusion ("something screwy here"), he consciously or unconsciously tries to make corrections, and becomes useless.

Although work with this type of illusion does not cause stomach upsets, migrainous headaches, or temper tantrums in observers, as experiments with "reversible staircases" and reseau patterns sometimes do, it occasionally produces feelings of perplexity and insecurity from which recovery may be rather slow.

Inferences from the data discussed above suggest the existence of a cessational sequence illusion, perhaps complicated by after-images and memory effects, but no evidence of this has been observed by the writer or reported to him.

Miscellaneous auditory illusions, usually of the clicking of switches, have been reported to accompany the sequence illusion.

PRACTICAL PROBLEMS.

Preliminary Discussion.

The existence of a sequence illusion suggests that whenever a number of stimuli are perceived within a small fraction of a second, probably smaller than 100 ms. under normal circumstances, impressions of either simultaneity or sequence may be entirely erroneous, even though all, or a majority, of the observers are in agreement as to the phenomenon perceived.

In some instances, such as in connection with studies of lightning flashes, instruments can be substituted for the human eye, and the errors attributable to illusions can be minimized. Some other observations, for which suitable instruments are not yet available, must still be made by eye, and conclusions from these observations should include an "error factor" sufficient to allow for any illusory sequence effects.

The Firefly Problem.

Numerous observers report that fireflies on occasion flash in approximate synchronism. Recent careful observations, summarized by Alexander,[3] indicate that the perceived flashing is not in true synchronism, but is "a pulse of light that moves with great rapidity across the field of vision from one side to the other." This is approximately what would be perceived if the fireflies were flashing in true synchronism, the "pulse" of illumination being due to the sequence illusion.

It is here suggested that the fireflies are flashing in very nearly absolute synchronism, the timing being a "mass rhythm" phenomenon, and that the supposed "pacemaker" is actually a proximal firefly, which, being close to the observer, has a greater effective brightness, and hence is perceived slightly sooner than the others.

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[3] Alexander, Gordon (1935), "Is a Pacemaker Involved in Synchronous Flashing of Fireflies?," *Science*, N. S., Vol. 82, No. 2132, p. 440.

According to this concept, the various observers have been consistently reporting an optical illusion, rather than a natural curiosity. It should be noted, however, that consideration of this illusion does not preclude the possibility of a "pacemaker," but only suggests that if such a pacemaker exists, the reaction time of the common firefly to visual stimuli is phenomenally short. It seems probable that with modern high-speed photoelectric measuring equipment the reaction time of the firefly could be measured, and the status of the hypothetical pacemaker more accurately determined.

Correction For Illusion.

Preliminary considerations suggest that the perception time of a given observer to a given stimulus could be determined, and that observations by him could then be corrected, on the basis of this determination, for his individual "perceptional lag." However, well-known experiments show that the "personal equation" is by no means a constant, being affected by numerous factors, such as fatigue, state of nutrition, position, phasing of the subject's emotional cycle, and the residual effects produced by minor irritations, such as a "wrong number," a wrinkled sock, or dirty glasses.

In view of these factors, it appears that correction of a single observation for the observer's perceptional lag is not likely to be of much use, but that correction of a large number of observations, made at many times, for the observer's average perceptional lag, determined from many tests, may lead to more accurate results.

CONCLUSIONS.

Major reported features of the sequence illusion, whether simple or complex, can be reasonably explained by application of well-known physical and physiological principles.

Somewhat inconclusive evidence suggests that perceptional lag is a quasilogarithmic function of the reciprocal of stimulus intensity.

Consideration of various omitted factors, such as the unequal sensitivity of various parts of the visual field, will apparently have little effect on the foregoing explanation of the sequence illusion.

The existence of this sequence illusion casts doubt on any reports of both sequence and synchronism when the stimuli all occur within a small fraction of a second, assumed to be of the order of 100 ms.

Correction of a single observation for the observer's perceptional lag as determined from a single test seems useless. When many observations are corrected for the average lag, as determined from many tests, some increase in accuracy may theoretically be expected.

The foregoing discussion strengthens the widely-held opinion that insofar as possible instruments should be substituted for the human perceptional mechanisms when accurate results are desired.

Further investigation of illusions of this type, conducted in a well-equipped laboratory, and with an adequate supply of observers, should lead to interesting results.

Announcement from the Lalor Foundation.—The Lalor Foundation announced recently the program of its fifth series of Fellowship Awards in Chemistry to be granted for the academic year 1941–42. Four post-doctorate awards of a value of $2,000 each and two awards of $2,500 each have been authorized. The awards are open to both men and women. The recipient of an award must have the equivalent of a Ph.D. degree and the applicants will be judged by their previous training, demonstrated competence and promise in their special fields of work. Detailed information and application forms may be obtained by addressing C. Lalor Burdick, Secretary of the Lalor Foundation, Wilmington, Delaware. Applications should be filed before December 31, 1940 and appointments will be announced early in 1941.

R. H. O.

Chemists Study Vanilla.—Research is now trying to improve on traditional rule-of-thumb methods to get out of vanilla beans more of the extract that housewives use as a flavoring. Chemists of the U. S. Department of Agriculture have already found that treatment with ethylene gas hastens curing and improves the product. The Mexican method of curing—used in America since the days of the Aztecs, who discovered the vanilla plant—is to dry the pods or beans in the sun. The Bourbon process, which is to dip the beans into hot water, is used in Madagascar and other French islands, which supply most of the world's vanilla. These methods with local ramifications, have been matters of custom for many years. It now appears that there is a scientific basis for some of the traditional rule-of-thumb procedures. There is no vanillin in the green beans but it was learned long ago that it develops during the curing. The Department is now studying vanilla growing at the United States Agricultural Experiment Station at Mayagnez, Puerto Rico, and workers find that vanilla beans treated with ethylene gas and hot water and then dried in an electric oven cure much faster than with the old treatments. Vanillin apparently is not the only important flavoring material in the plant, as the typical "fruity" vanilla fragrance develops only after long conditioning.

R. H. O.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

FILTER PAPER SUPPLY IN THE UNITED STATES.

According to the results of a survey made by the Bureau, it appears that no interruption in supply of high-grade analytical filter paper in the United States is likely. Heretofore much of this paper has been imported, and the survey was made because of the possibility of the European situation causing serious interruption of supply of foreign papers. According to the information received, while this has occurred to a considerable extent, much foreign paper is still being received, and manufacture of the higher grades has been undertaken in the United States. The following is a resume of the situation:

Shipments of the English Whatman papers to this country since the beginning of the war have been approximately twice normal and are now running about three times normal.

The supply of Swedish Munktell papers is somewhat depleted but regular shipments are expected in the near future.

The Baker and Adamson paper is made in this country from stock purchased in Sweden. It is of the same grade as the highest grade of foreign paper. No information was received as to continuance of supply of it.

The supply of the German Carl Schleicher and Schull paper is much depleted but all of the various grades of it are now being made in this country by the American firm of the same name from stock made in American paper mills. Examination of these papers indicated that they compared favorably with the German product. Thorough tests were made of the highest grade, the double acid-washed papers, and the papers tested were found to be as good and in some respects better than the German papers. While the various kinds of the American papers bear the same designations as the German papers, the American concern stated that they had no connection with the German firm, and furthermore that they "want to make American filter papers the best in the world," as they propose to remain in the business permanently.

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* Communicated by the Director.

The Eaton-Dikeman Co., a domestic manufacturer of filter papers made from paper stock also produced by them, have made the lower grades of analytical papers for a number of years. They have now expanded their grades up to single acid-washed papers. Examination of these papers by the Bureau indicated that they also compare favorably with the foreign papers. They state that they have the development of double acid-washed papers under way, and that they expect to be able in the near future to supply papers equal to all grades of the foreign papers.

INSPECTION OF PIPE COATINGS.

The field work of the tests of protective coatings undertaken jointly by the American Petroleum Institute, coating manufacturers, and the Bureau has been completed. Only four of the 16 test sites proved to be severely corrosive. Unprotected pipe would apparently last indefinitely in some of the soils. The conductance and pattern tests as well as the condition of the pipe indicate that there is a continual decrease in the effectiveness of most of the coatings tested.

The tests indicate that no bituminous or reinforcing material was superior to all others, and the relative effectiveness of most of the coatings was not the same at all sites. At most of the test sites the condition of all of the coated pipe was better than that of the unprotected pipe, but in several instances deeper pits were found on the coated lines than on the adjacent uncoated ones.

Although all coatings reduced the total corrosion to some extent and most of them prevented serious pitting at most of the sites during the 10-year period of the test, no coating prevented all corrosion at all test sites.

The effectiveness of the coatings was roughly proportional to their thickness, but two coatings of approximately the same thickness sometimes differed considerably in effectiveness.

DISCHARGE COEFFICIENTS OF FLOW NOZZLES.

For over five years the Special Research Committee on Fluid Meters of the American Society of Mechanical Engineers

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19

has conducted a research program on flow nozzles. Early this year the tests for determining nozzle discharge coefficients were completed. In correlating the results, attempts to apply analytical methods were unsuccessful, and an entirely graphical procedure was found to be the only practical one.

The value of the discharge coefficient of a flow nozzle depends upon the ratio of the nozzle throat diameter to the pipe diameter, the character of the fluid flow as defined by the Reynolds number, and to a slight extent upon the absolute size of the metering element as determined by the diameter of the pipe in which the nozzle is used. Since on ordinary coordinate paper the coefficient can be plotted against only one of these three factors at a time, the graphical correlation method requires a great deal of tedious cross-plotting. Another element to be considered is that the Reynolds number may be computed for either the nozzle throat diameter or the pipe diameter, and the former multiplied by the diameter ratio equals the latter. Either of the Reynolds numbers may be used throughout the correlation process, and the final results obtained with one should agree with those obtained with the other when adjusted by means of the diameter ratio relation just given.

In order to minimize as far as possible, the effects of individual judgment in the correlation of nozzle coefficients, three members of the subcommittee which has directed the flow nozzle research, have made separate analyses. The results have been compared and averaged, and the averaged results, in the form of curves, will be presented at the annual meeting of the American Society of Mechanical Engineers in December. These coefficient curves apply to flow nozzles in pipes 2-inches in diameter and larger, and for pressure connections located one pipe diameter preceeding and one-half pipe diameter following the inlet face of the nozzle. The curves cover a diameter ratio range from 0.2 to 0.85, and a Reynolds number range, based on the nozzle throat diameter, from 50,000 to 5,000,000.

From the standpoint of commercial use, the range at conditions covered by these curves is the most useful. However, the test data obtained by the committee extend to Reynolds numbers as low as 1,000, and for corner pressure connections also. Therefore, in later reports analyses will be presented covering the entire range of conditions for which there are test data. Tabulated summaries of the test results will also be given.

A MICROMANOMETER OF THE POINTER GAGE TYPE.

During recent research by Francis C. Morey on the discharge coefficients of flow nozzles, a micromanometer was constructed for measuring the differential pressure produced by the nozzles in a water pipe line at low flows. An instrument was desired which would be capable of measuring differential pressures in the range from 0.1 inch to 10 inches of water with an accuracy of at least 0.2 per cent. Existing designs were found unsuitable because of limited range, or because they employ glass observation tubes of relatively small diameter, in which chemical cleanliness is essential.

The micromanometer is simply a water-filled inverted U-tube monometer utilizing pointer gages to locate the water surfaces. The pointers are operated by micrometer screws which measure the vertical distance between these surfaces. The measuring columns consist of glass cylinders approximately 6 inches in diameter and 15 inches long. The pointers enter through packing glands at the bottom of the cylinders.

Proper control of illumination makes possible very exact setting of the pointers. The micrometer head gives direct readings to 0.001 inch, and with steady pressure the observations may be repeated to approximately 0.1 division.

ABSOLUTE PRESSURE CALIBRATIONS OF MICROPHONES.

In the *Journal of Research* for November (RP1341), Richard K. Cook describes experiments proving that a tourmaline crystal calibrated by application of the principle of reciprocity may be used as a primary standard source for the absolute pressure calibration of condenser microphones. The tourmaline crystal disc was used both as a sound receiver (direct piezoelectric effect) and as a sound source (converse piezoelectric effect). In accordance with the reciprocity principle that the direct and converse piezoelectric moduli are equal, the output of the crystal as a sound source was computed from its response when used as a sound receiver (microphone), and vice versa. Therefore, the application of this principle to acoustic measurements yielded an absolute determination of the piezoelectric modulus of tourmaline under hydrostatic pressure. The tourmaline crystal was used to calibrate a condenser microphone.

The same principle of reciprocity was applied to the action of the condenser microphone itself, thus obtaining an independent absolute measurement of the response of the microphone as a function of frequency.

This principle of reciprocity corresponds to the reciprocal theorem used in electrical engineering. Other special cases of the principle are well known in applied mechanics and in acoustics.

It was proved experimentally that the tourmaline disc and the condenser microphone satisfied the principle of reciprocity, and that the reciprocity calibrations agreed with electrostatic actuator, pistonphone, and resonant tube calibrations, but not with thermophone calibrations.

A MULTIPURPOSE PHOTOELECTRIC REFLECTOMETER.

Measurements of color, apparent reflectance, and specular gloss are used in the ceramic, paint, textile, paper, and chemical industries to help describe in numerical terms the appearance of materials. A multipurpose reflectometer to measure these quantities photoelectrically has been designed by R. S. Hunter of the Colorimetry and Spectrophotometry Section, and is described in the November number of the *Journal of Research* (RP1345).

Of the many different uses of the apparatus, the following may be mentioned: The instrument measures the apparent reflectance, the hiding power, and the opacity of paints, papers, and porcelain enamels. Measurements with it will help in evaluating the efficiency of soaps and detergents for cleaning fabrics. With the proper spectral filters, the device may be used in determining the magnitude and character of color differences between samples which are similar to each other in color. Settings with these filters provide a basis for evaluating the whiteness, yellowing, fading, bleaching, blueing, and tinting strength of textile materials. With different filters, chosen to transmit narrow spectral bands, the reflectometer may be used for abridged spectrophotometry. Values of specular gloss measured with the instrument are used to evaluate the shininess of surfaces and to classify paints and other materials for gloss. With an attachment which has been designed, the instrument will measure the transmissions of non-diffusing liquids, glasses, and plastic samples.

Design of the instrument was undertaken because the Porcelain Enamel Institute needed a device to measure both 45°, 0° luminous apparent reflectance (required by the P. E. I. standard reflectance test for porcelain enamels) and 45°, −45° specular gloss (required by the P. E. I. standard tests for acid resistance and surface abrasion resistance of porcelain enamels). The Bureau has cooperated with the Porcelain Enamel Institute in the development of these tests and as a part of this cooperation undertook in 1936 to design improved apparatus.

In the reflectometer, two light beams from a single source are directed along separate paths to two barrier-layer photocells. The operating characteristics of a number of barrier-layer photocells were analyzed to determine which types were most suitable and how to use them most advantageously. A substitution null method, employing a galvanometer to indicate equality of the currents generated by the two photocells, was finally chosen. For each sample tested, there is a photometric adjustment to restore equality of currents. The amounts of photometric adjustment are measured on the direct-reading scales, one of which is used for apparent reflectance and the other for specular gloss. Because of its high precision, the reflectometer is especially suited for measuring small differences in apparent reflectance, gloss, or color of nearly identical samples.

SOLAR ECLIPSE.

A preliminary report received from Irvine C. Gardner, leader of the eclipse expedition to Patos, Brazil (see Technical News Bulletin 282, October, 1940) states that a cloudy sky interfered with the observations. The morning of October 1 was absolutely clear but heavy cloud formed later in the day so that at first it was feared that no photographs whatever could be obtained. However, the clouds gradually lightened so that five or six exposures were made of the inner corona through clouds. Since no extensions of the corona are visible it is feared that the pictures will not be of much scientific value. No exposure was made of the flash spectrum. It is believed that satisfactory data were obtained on the times of contacts and on radio conditions. Within ten minutes after the eclipse, the entire western sky cleared.

The complete account of the expedition will be published by the National Geographic Society.

A New Heat Transfer Medium.—W. E. KIRST, W. M. NAGLE AND J. B. CASTNER. (*Chemical and Metallurgical Engineering*, Vol. 47, No. 7.) A molten mixture of nitrates and nitrites of sodium and potassium, known as HTS has recently come into large plant-scale use as a heating and cooling liquid. This mixture, which consists of approximately 40 per cent. $NaNO_2$, 7 per cent. $NaNO_3$ and 53 per cent. KNO_3, by weight has been adopted because it has a low melting point, a high heat transfer rate, and a thermal stability and a lack of corrosive action on steel at temperatures above those obtainable with Dowtherm, hot oil or steam. While similar nitrite and nitrate mixtures have been employed for a great many years in molten baths for heat treatment of metals and in small installations requiring heat removal at a high temperature level, their use as heat transfer salts on a large scale began with the installation of the Houdry units for the catalytic cracking and refining of petroleum. In 1937 this salt mixture was evaluated by Socony-Vacuum Oil Co. and Sun Oil Co. in semi-commercial cracking plants and the first full-size Houdry unit began operation in 1939. There are now at least twelve of these large catalytic cracking plants in operation, and others are being built. Since this first adoption in the Houdry cracking units, many new uses have been suggested. For example, it has been employed in the new Thermofor Kiln, developed by the Socony-Vacuum Oil Co. for the regeneration of decolorizing clays. In this process the clay is held at the desired temperature by pipes through which the molten salt is pumped in circuit with an exchanger for introducing or removing heat as the need may be. This salt mixture is also suitable for use in a high-temperature bath for cleaning high melting plastics from metal parts. HTS appears attractive for many high temperature distillations, the heat to the still being supplied by circulating the molten salt through pipe coils in the base of the still.

R. H. O.

THE FRANKLIN INSTITUTE.

STATED MONTHLY MEETING, NOVEMBER 20, 1940.

The regular monthly meeting of The Franklin Institute was called to order at 8:15 o'clock by Dr. Philip C. Staples, President.

The minutes of the previous meeting were approved as printed in the November issue of the JOURNAL.

The Secretary reported the following additions to the membership since the last meeting:

Active	12
Associate	11
Student	31
Total	54

There being no further business the Chairman introduced Dr. Ellice McDonald, Director of the Biochemical Research Foundation, who presented his fifth annual report to the membership of the Institute.

He outlined briefly the organization of the laboratory and the activities of the several departments. He also described the new laboratory building which is now nearing completion at Newark, Delaware. This portion of the report was illustrated with lantern slides. Mention was made of the year's progress in scientific investigation, which included the study of giant molecules, glutamic acid, phosphatase, ribose, and soil bacteria, as well as experiments and studies with the cyclotron.*

At the conclusion of the report the Chairman extended the thanks of the members to Dr. McDonald.

Adjourned,

HENRY BUTLER ALLEN,
Secretary.

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* For full report see page 727.

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of Stated Meeting held Wednesday, November 13, 1940.*)

HALL OF THE COMMITTEE,
PHILADELPHIA, NOVEMBER 13, 1940.

DR. FREDERIC PALMER, JR., *in the Chair*

The following report was presented for final action:

No. 3069: Fluid Measuring System.

This report recommended the award of an Edward Longstreth Medal to Benjamin J. Wilson, of Philadelphia, Pennsylvania, "In consideration of his development of an integrating and recording flowmeter of high precision, embodying physical principles not hitherto used for this purpose."

JOHN FRAZER,
Secretary to Committee.

LIBRARY NOTES.

The committee on Library desires to add to the collections of the Institute any technical writings of members who have had occasion to publish such material.

Literary contributions from author-members will be gratefully acknowledged, properly inscribed and noted in the Journal of the Institute.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 8½ × 11 inches is forty cents.

The library and reading room are open on Mondays, Tuesdays, Fridays and Saturdays from nine o'clock A.M. until five o'clock P.M., Wednesdays and Thursdays two until ten o'clock P.M. 800 readers made use of the facilities during the twenty-seven days of October.

RECENT ADDITIONS.

AERONAUTICS.

BRIMM, DANIEL J., AND H. EDWARD BOGGESS. Aircraft Maintenance. 1940.

BIOGRAPHY.

ANDERSON, FLORENCE BENNETT. A Grandfather for Benjamin Franklin. 1940.

BIOLOGY AND BIOCHEMISTRY.

PRESCOTT, SAMUEL CATE, AND CECIL GORDON DUNN. Industrial Microbiology. First Edition. 1940.

CHEMISTRY AND CHEMICAL TECHNOLOGY.

BALDWIN, ERNEST J. Principles of Inorganic and Analytical Chemistry. 1940.
HAINBACH, RUDOLF. Pottery Decorating. Second Revised English Edition. 1924.
HAUSER, ERNST A., AND J. EDWARD LYNN. Experiments in Colloid Chemistry. First Edition. 1940.
HILDITCH, T. P. The Chemical Constitution of Natural Fats. 1940.
Kingzett's Chemical Encyclopædia. Sixth Edition. 1940.
MCPHERSON, WILLIAM, AND OTHERS. Chemistry. 1940.

EDUCATION.

ADDISON, AGNES, Editor. Portraits in the University of Pennsylvania. 1940.
CHEYNEY, EDWARD POTTS. History of the University of Pennsylvania, 1740–1940. 1940.
DOWLIN, CORNELL M., Editor. The University of Pennsylvania Today. 1940.

ELECTRICITY AND ELECTRICAL ENGINEERING.

COLLINS, A. FREDERICK. The Radio Amateur's Handbook. Eighth Edition. Revised by E. L. Bragdon. 1940.

NEILL, HUMPHREY B. Forty-Eight Million Horses. 1940.
PAGE, LEIGH, AND NORMAN ISLEY ADAMS, JR. Electrodynamics. 1940.

ENGINEERING.

TIMOSHENKO, S., AND GLEASON H. MACCULLOUGH. Elements of Strength of Materials. Second Edition. 1940.

GEOLOGY AND GEOPHYSICS.

HEILAND, C. A. Geophysical Exploration. 1940.
TWENHOFEL, W. H. Principles of Sedimentation. 1939.

HYGIENE.

SHRADER, JAMES HOUSTON. Food Control. 1939.

INDUSTRIAL MANAGEMENT.

WALTON, ALBERT. The New Techniques for Supervisors and Foremen. 1940.

MARINE ENGINEERING.

United States Naval Institute. Energy Analysis of Naval Machinery. 1940.

MATHEMATICS.

BELL, E. T. The Development of Mathematics. First Edition. 1940.
QUINE, WILLARD VAN ORMAN. Mathematical Logic. 1940.

MECHANICAL ENGINEERING.

Brown and Sharpe Mfg. Co. Practical Treatise on Milling and Milling Machines. 1940.
GUILLET, GEORGE L. Kinematics of Machines. Fourth Edition. 1940.

METALLURGY AND MINING.

American Bureau of Metal Statistics. Yearbooks for 1927 and 1939. Eighth and Twentieth Annual Issues. 1928, 1940.
American Institute of Mining and Metallurgical Engineers. Transactions. Iron and Steel Division. 1940.
Mineral Industry during 1939. 1940.

PHOTOGRAPHY.

HART, C. A. Air Photography Applied to Surveying. 1940.

REFRIGERATION.

American Society of Refrigerating Engineers. The Refrigerating Data Book. Volume 2. 1940.

SANITARY ENGINEERING.

BABBITT, HAROLD E., AND JAMES J. DOLAND. Water Supply Engineering. Third Edition. 1939.

TECHNOLOGY—HISTORY.

BURLINGAME, ROGER. March of the Iron Men. 1940.

NOTES FROM THE BARTOL RESEARCH FOUNDATION.

ON THE INTERPRETATION OF NEUTRON MEASUREMENTS IN COSMIC RADIATION.*

BY

H. A. BETHE,† S. A. KORFF AND G. PLACZEK.†

The measurements of cosmic-ray neutrons are essentially determined by the energy distribution of neutrons in the atmosphere. The various factors influencing this distribution are investigated. It is found that diffusion equilibrium exists in the atmosphere except for about one meter of water at the top and one meter above ground. It is probable that the energy distribution below 100 kev can be represented by a simple diffusion formula; it does not contain an appreciable number of thermal neutrons. The calculation of the number of neutrons originally produced from the present experimental data is uncertain because of capture of fast neutrons. As an example of the influence of the ground, the neutron distribution is calculated in the air above a water surface. Measurements in the water may be most suitable for a quantitative determination of the neutron intensity.

The various experimental arrangements are discussed. A $1/v$-detector such as a BF_3 counter measures essentially the density of neutrons if care is taken to minimize the effect of recoil nuclei by using a high bias. The evaluation of experiments using hydrogenic material to slow down the neutrons is discussed. From these two types of experiments, provisional results for the neutron production are obtained which are in agreement with each other. From the altitude distribution of neutron intensity it can be concluded that the production of neutrons of very long range is not very im-

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* An abstract of an article published in full in the Physical Review **57**, 573 (1940).

† Cornell University, Ithaca, New York.

portant. The role of neutrons for the energy budget of cosmic radiation is discussed.

ON THE CONTRIBUTION TO THE IONIZATION AT SEA-LEVEL PRODUCED BY THE NEUTRONS IN THE COSMIC RADIATION.*

BY

S. A. KORFF.

Since neutrons constitute a numerically important component of the cosmic radiation,[1] the question arises as to the amount of ionization in the atmosphere at sea-level which they produce. This ionization will be produced in two ways: (*a*) By recoil-nuclei produced by the neutrons in collisions; and (*b*) by the ionizing radiation ejected from nuclei as a result of neutron-induced disintegrations. We may set limits to each of these contributions.

It is believed that most of the neutrons in the atmosphere at sea-level are evaporated out of nuclei by the high-energy cosmic radiation, and have initial energies of 10 to 30 Mev. It has been pointed out by Bethe, Korff, and Placzek [2] that these neutrons will first be inelastically scattered by nitrogen nuclei. In this process, the neutron enters the nitrogen nucleus, causes the ejection of one or more nuclear particles, and usually emerges with about four Mev. energy. The bulk of the energy of the neutron is used in breaking up the binding of the nucleus, and hence is not transformed into ionization. The ionizing particles which are emitted will in general have energies which are small compared to the initial energy of the neutron, and it may be estimated [2] that of the order of five Mev. per neutron will appear as ionization.

The measurements of the Montgomerys [3] show that at sea-level the rate of production of neutrons in air is $q = 10^{-7}$ neutrons per cc. per second. Hence the ionization produced by the process just described will be $q \times (5 \times 10^6)/32$ or 1.6×10^{-2} ions per cc. per atmosphere per second.

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* Condensed from an article published in full in *Terrestrial Magnetism and Electricity*, page 133, June, 1940.

[1] S. A. Korff, *Rev. Mod. Phys.*, 11, 211–219 (1939).

[2] H. A. Bethe, S. A. Korff and G. Placzek, *Phys. Rev.*, **57**, 573–587 (1940).

[3] C. G. and D. D. Montgomery, *Phys. Rev.*, **56**, 10–12 (1939).

The neutron, after inelastic collisions have slowed it down to below four Mev., will then lose energy by elastic collisions and will be slowed down until its energy is of the order of one volt or less. Hence the four Mev. will appear as ionization, produced by the recoiling nuclei and again, multiplying this figure by the number of neutrons, we obtain 1.3×10^{-2} ions per cc. per second as the contribution due to this process.

The slow neutrons will then be absorbed by the $N^{14}(n, p)$-reaction, giving rise to a proton of about one-cm. range. This proton will produce $\sigma = 10^4$ ions along its path. Therefore, the contribution to the total ionizations by these protons will be $q\sigma = 10^{-3}$ ions per cc. per sec. Hence we cannot account for more than 3×10^{-2} ions per cc. per atmosphere per second of ionization produced at sea-level by neutrons in the atmosphere.

We must now consider whether any contribution arises from neutrons produced in the ground which might cause the ejection of radiation upward. Immediately above the Earth's surface, it can be shown that such gamma rays will produce 10^{-2} ions per cc. per second. This represents an upper limit for the radiation due to artificial radioactivity induced by cosmic-ray neutrons. Adding all the above amounts, the total ionization produced at sea-level due to all the effects produced by neutrons will not exceed 4×10^{-2} ions per cc. per second. This is to be compared to the figure of about 1.5 ions produced by the ionizing cosmic radiation at sea level.

Finally, the number of neutrons is roughly equal to that of the charged particles. Since each will most probably be eventually captured by nitrogen, nitrogen will be disintegrated, forming long-lived C^{14} at a rate of $q = 10^{-6}$ atoms per cc. per second in the upper atmosphere. Hence the length of time t before an appreciable fraction (one per cent.) of a new isotope is formed is $(NP/q) \times 10^{-2}$, where N is the Lochschmidt number, and P is the pressure in atmospheres. In this case t is 10^{14} years, a period long compared to the supposed life of C^{14}. Similarly, in the oceans, neutrons will be captured by hydrogen, forming heavy water at roughly this same rate. Hence we must conclude that the neutrons in the cosmic radiation cannot be invoked as an explanation of the origin of certain isotopes in the Earth's crust, nor will they provide more than four per cent. as much ionization at sea-level as the ionizing cosmic radiation produces.

The author is indebted to O. H. Gish for helpful discussions.

MEASUREMENTS OF DISCHARGE CHARACTERISTICS OF GEIGER-MUELLER COUNTERS.*

BY

W. E. RAMSEY.

An experimental method is presented for determining directly the voltage-time relationship of a counter wire during the interval which begins with the initiation of the discharge and ends when the wire has achieved its maximum negative potential. The procedure allows for the measurement of times ranging from 2.0×10^{-7} second to 1.0×10^{-4} second, and wire potentials between 20 volts and 350 volts. Studies indicate that over a considerable range of wire and cylinder voltages and wire system capacities the relation $E = -(Q/c) \log_{10} (t/t_0 + 1)$ satisfactorily represents the observations. Here E is the potential of the counter wire, t the time, Q a function of cylinder voltage and t_0 a constant for a given counter. t is, of course, measured from the instant when $E = 0$. It follows from this relation that the current in the counter is inversely proportional to the time (for $t \gg t_0$, which is of the order of magnitude of 3.0×10^{-8} second). In a particular case where conditions are such that the counter "overshoots" (the voltage pulse $E_{\text{max.}}$ from the counter exceeds in magnitude the difference between starting potential and cylinder potential) experiment reveals Q to vary with the cylinder potential and with the capacity of the wire system in a manner determined by $Q = cE_{\text{max.}}/\beta$, where β is a constant and the dependence upon cylinder potential is contained in the dependence of $E_{\text{max.}}$ upon that quantity. For this case of overshooting, the foregoing formula results in

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* Abstract of an article published in full in *The Physical Review*, **57**, 1022 (1940).

$t = t_0(10^{\beta E/E_{\text{max.}}} - 1)$. If we confine ourselves to constant values of the cylinder voltage, the corresponding Q's are constant, so that $cE_{\text{max.}}$ is constant and we may consequently write $t = t_0(10^{Ec/Q} - 1)$ where Q does not vary with c. These expressions for t have been established by the experiment only for $|E|$ not in excess of $0.8|E_{\text{max.}}|$ and for $t > 2.0 \times 10^{-7}$ second. Discharge characteristics were measured for a series of pressures of an argon-oxygen mixture and in each case a relation of the logarithmic form indicated was found to represent the data. An argon-alcohol counter, generally spoken of as "self-quenching," has characteristics of the same form. When cylinder voltage is adjusted for equality of pulse size, t_0 is inversely proportional to pressure.

THE DISCHARGE MECHANISM OF GEIGER-MUELLER COUNTERS.*

BY

C. G. MONTGOMERY AND D. D. MONTGOMERY.

The measurements of W. E. Ramsey on the variation with time of the potential across a Geiger-Mueller counter (see preceding paper) are interpreted on the basis of the inductive action of the positive ion space charge moving across the counter. This inductive action, together with the hypothesis that the positive ions may eject electrons when they reach the cathode, furnishes a reasonable explanation of both the fast and slow types of breakdown of counters. This postulated mechanism leads to simple explanations of the quenching of a counter discharge and the necessary conditions for the maintenance of a steady discharge. In particular, it is predicted and verified experimentally that it is possible to operate a counter even when the potential is considerably in excess of that required for a continuous discharge, provided that the capacity of the counter wire is sufficiently reduced. A simple, although indirect, method is described for measuring the breakdown characteristic of a counter which gives results in good agreement with the direct determinations of W. E. Ramsey.

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* An abstract of an article published in full in *The Physical Review*, 57, 1030 (1940).

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

Ultracentrifugation of Ragweed Pollen Extracts.—EDWARD B. SANIGAR. Ultracentrifuge examinations were made of a number of ragweed antigen solutions for the characterization of the extracts by particle size, on the assumption that the active material is protein in nature. These solutions had been prepared by Dr. John M. Newell of the Cytology Department during the course of a biochemical study of ragweed antigen. Most of the extracts examined in the Svedberg oil-turbine ultracentrifuge showed marked heterogeneity in particle size. In no instance was complete separation of a sedimenting boundary from the meniscus obtained, showing that most of the material present in the extracts was of small particle size.

Ragweed Extracts Nos. 21, 21A and 22, for which ultracentrifuge and absorption curves are given, were prepared as follows from pollens of high ragweed (*Ambrosia trifidia*) and low ragweed (*A. artemisiae folia*), kindly supplied by Dr. W. Cook Spain of New York City. A mixture of 1.5 g. of each of the pollens was extracted several times with 3–10 cc. portions of ether to remove fats. After defatting, the pollen was dried and then extracted for two hours at room temperature with a solution containing 0.5 g sodium chloride and 0.275 g. sodium bicarbonate per 100 cc. solution. The extract was filtered through hardened (Whatman No. 50) filter paper, and the residue re-extracted with a small volume of the sodium chloride-bicarbonate solution and filtered through the same filter paper, the filtrates being combined to give Extract No. 21. A few drops of chloroform were added as preservative and the extract passed through a Seitz filter, after which it was stored in a refrigerator until examined.

The extracted pollen was re-extracted with 50 cc. of the alkaline saline solution and this solution was filtered through a 6 per cent. collodion membrane. This filtrate, Extract No. 21A, was used for the determination of the absorption spectrum given below. Some of Extract 21A was ultrafiltered to dryness under 70 lb. pressure through No. 1200 Cellophane. 1.0 g. of this residue was extracted with two 10 cc. portions of a 0.5 per cent. sodium chloride solution (buffered to a pH of 7.0) and filtered through Whatman No. 50 filter paper and then through a 6 per cent. collodion membrane, giving Extract No. 22.

Nitrogen analyses (Kjeldahl) were made on Extracts 21 and 22 by precipitation of known amounts of the extracts with phosphotungstic acid solution, centrifuging out the precipitate and digesting the precipitate for the protein nitrogen content and the supernatant liquor for the non-protein nitrogen content. As will be seen from the data in Table I, Extract 21 was much more concentrated than Extract 22, although both were extremely potent from the standpoint of allergic activity. Both extracts were diluted 1 : 50 and tested on the arm of a susceptible person; all the solutions gave strong positive reactions.

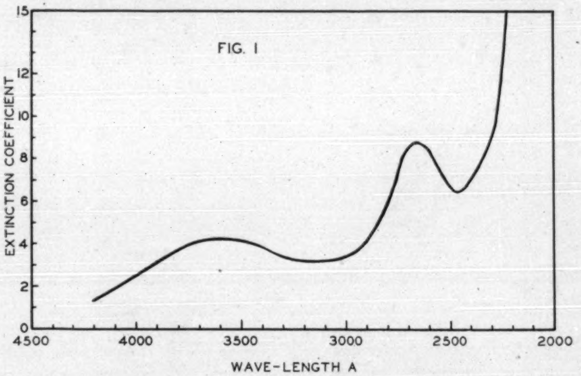
TABLE I.

Extract.	Nitrogen Content.		Ultracentrifuge Data.			
	Protein Nitrogen mg. *N*/cc.	Non-protein Nitrogen mg. *N*/cc.	Speed R.p.m.	Cell Temp.	Cell Thickness.	Scale Distance.
21	1.25	1.27	58,000	34.3° C.	3 mm.	14 cm.
22	0.36	0.13	59,000	34.3° C.	3 mm.	14 cm.

Ultraviolet absorption spectra were obtained, by means of a Bausch and Lomb all-quartz spectrograph, using quartz notched echelon cells. The spectrum of Extract 21A diluted to half strength, shown in Fig. 1, indicates, by the absorption at 2700 Å., the presence of at least a protein-like constituent in the extracts. This is in keeping with the fact that such extracts can be divided into fractions of different solubilities by 50 per cent. saturation with ammonium sulfate, can be completely precipitated by saturation with ammonium sulfate and by other protein-precipitants, and can be ultrafiltered using Cellophane membranes which allow sucrose to pass through. The antigen is, however, thought by some investigators to be a carbohydrate rather than a protein.

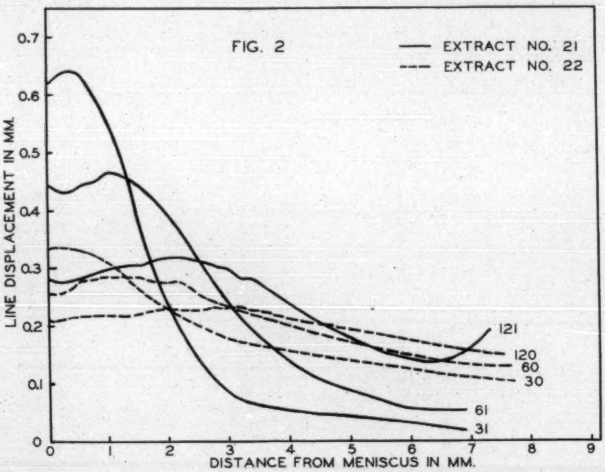
V. 19

The conditions used during the ultracentrifuging of Extracts 21 and 22 are given in Table I, and some of the sedimentation curves obtained shown in Fig. 2. These sedimentation diagrams, while in general typical, are rather better than those obtained for the other extracts examined. The flatness of the curves indicates that the particles of ragweed antigen are of small molecular size. The curves also show the marked heterogeneity in particle size of the extracts, the particles ranging in size from large ones which travel to the bottom of the centrifuge cell to particles so small that they never leave the meniscus of the solution being centrifuged under the conditions stated (a speed of 59,000 r.p.m. with the centrifuge used corresponds to an average centrifugal force in the cell of about 250,000 times gravity.) The bulk of the particles in the extracts are of low particle size—low molecular weight. In only one instance (*viz.* Extract 21) were the curves adequate to warrant the calculation of an approximate value of s_{20} (the sedimentation constant reduced to the viscosity of water at 20° C.; see "The Ultracentrifuge" by Svedberg and Pedersen, Oxford University Press, 1940). Based on the 31



Ultraviolet absorption spectrum of ragweed pollen Extract 21A.

min. and 121 min. curves for Extract 21 an approximate s_{20} of 1×10^{-13} cm. sec.$^{-1}$ dyne^{-1} was calculated for the bulk of the material which seems most characteristic of the ragweed



Ultracentrifuge sedimentation diagrams of ragweed pollen extracts. The figures at the ends of the curves represent the time in minutes from the application of the final driving pressure to the rotor.

extracts. This is a very low value for the sedimentation constant of a protein (cf. s_{20} serum albumin, 4.4×10^{-13}; serum globulin, 7.1×10^{-13}) and would indicate a molecular weight for the particles of considerably less than 17,000 (for which particles s_{20} has a value of 1.9×10^{-13}). Since naturally occurring proteins of size larger than the above, on being broken down, frequently give heterogeneous mixtures, it is of course conceivable that the ragweed antigen solutions, as examined above, were solutions of degraded natural products. However, since the methods of preparation were quite mild, this would hardly be so unless the naturally occurring ragweed proteins were quite unstable and very easily broken down into particles of many different sizes.

Studies on Plasma Phosphatase Activity in Relation to Fat Metabolism in Rats.—LEOPOLD WEIL AND MARY A. RUSSELL. (*Journal of Biological Chemistry*, **136**: 9, 1940.) Studies were made to find out the functional importance of plasma phosphatase in rats. Because of the limited blood supply of these animals, it was necessary to devise an ultra micro-method which enabled the carrying out of enzymatic determinations with less than 1 cmm. of plasma. Investigations by this method have shown that the presence of phosphatase in the plasma of albino rats is due to the ingestion of a certain part of the lipid fraction of the food. The ingestion of carbohydrate or of proteins did not result in an increased plasma phosphatase activity. An increase in the activity of the plasma enzyme occurred only when unsaturated fats or fatty acids were added to the diet. The saturated fatty acids and also the saturated dicarboxylic acids proved to be entirely ineffective. The experiments carried out with palmitic, stearic and cerotic acids in combination with sodium taurocholate, however, indicated that when the resorption was increased by emulsification the enzymatic picture was not changed. Chaulmoogric acid was found to be ineffective, and ricinoleic acid only slightly active; these phenomena are possibly due to their diarrheal action, and also possibly to the position of the double bond of the former acid. Linolenic acid was found to be highly active after ingestion, in contrast to the ineffectiveness of hexabromlinolenic acid, indicating the importance of the double bonds in this reaction. The degree of unsaturation seems to be of no decisive importance, since oleic, linoleic and linolenic acids were all active. Our investigations have also shown that a certain molecular magnitude of the unsaturated fatty acids is required in order to obtain an increased plasma phosphatase activity after ingestion. Elaidic acid, which is a geometric isomer of oleic acid, was found to be only slightly active compared with the marked activity of oleic acid. These results indicate that a certain natural configuration is necessary to produce this reaction. The negative result obtained with oleyl alcohol and the only slight effectiveness of oleicamide clearly demonstrate the necessity of the free carboxyl group. Cephalin was highly effective in restoring the plasma phosphatase activity after ingestion while lecithin was found entirely without action, a rather surprising observation, since both phospholipids contain unsaturated fatty acids. Factors responsible for this phenomenon require further investigations.

The mechanism of fat resorption has been extensively studied and strong evidence presented that the absorbed fatty acids are transformed into phospholipids within the intestinal mucosa as an essential step in the resynthesis of neutral fats. The phospholipids formed in this way are transported by the plasma to the various organs where they may be deposited or transformed to neutral fats to be decomposed according to the need of the body. It is probable that the increased plasma phosphatase activity following the ingestion of unsaturated fatty acids may be linked with the process of transformation of phospholipids to neutral fats. The fact, however, that the ingestion of only certain unsaturated fatty acids is connected with an increased plasma phosphatase activity suggests the possibility that a difference may exist between the metabolism of saturated and of unsaturated fatty acids.

p-Nitrobenzoyl-d(−)- and p-Aminobenzoyl-d(−)-Glutamic Acid.—HARRY C. WINTER. (*Journal of the American Chemical Society*, **62**: 3266, 1940). In the course of other experiments in this laboratory it was desirable to prepare p-aminobenzoyl-d(−)-glutamic acid of a high degree of optical purity. A review of the literature revealed that this compound had been prepared from d(−)-glutamic acid by Ivánovics and Bruckner but by a method which is known to be accompanied by racemization. An intermediate product, p-nitrobenzoyl-d(−)-glutamic acid, was reported by these authors to have a melting point of 170°. The corresponding derivative of the l(+)-enantiomorph had been reported previously by Van der Scheer and Landsteiner to have a melting point of 112–113°. This wide variation in the melting points of the two optical forms together with the fact that no analyses were reported for the d(−) form have left the purity of the product prepared by Ivánovics and Bruckner open to question. The optical properties of these compounds have not been reported.

p-Nitrobenzoyl-d(−)-glutamic acid was prepared in this laboratory by resolution of p-nitrobenzoyl-dl-glutamic acid by repeated recrystallization of the strychnine salt from aqueous solution. A good yield of the slightly soluble salt of the d(−)-enantiomorph was obtained. After removal of strychnine, the free acid derivative crystallized from aqueous solution in fine white needles which softened at 77° and melted at 115–116° (*Anal.* Calcd. for $C_{12}H_{12}N_2O_7$: N, 9.46. Found: N, 9.39). This shows good agreement with the melting point of the l(+)-derivative reported by Van der Scheer and Landsteiner. The specific rotation in aqueous solution containing 2 moles of alkali was found to be −16.02°.

p-Aminobenzoyl-d(−)-glutamic acid was prepared in this laboratory by the reduction of the nitro compound according to the method of Van der Scheer and Landsteiner for the preparation of p-aminobenzoyl-l(+)-glutamic acid. The compound crystallized from aqueous solution in clusters of microscopic needles (*Anal.* Calcd. for $C_{12}H_{14}N_2O_5$: N, 10.53. Found: N, 10.50). The melting point, 166–167°, was somewhat lower than that, 175°, reported by Ivánovics and Bruckner. The specific rotation in aqueous solution containing 2 moles of alkali was −27.4°; in 9 per cent. hydrochloric acid + 15.5°.

BOOK REVIEWS.

Elements of Strength of Materials, by S. Timoshenko and Gleason H. MacCullough. Second Edition, 365 pages, illustrations, 16 × 24 cms. New York, D. Van Nostrand Company, Inc. Price $3.25.

Many engineers are familiar with the first edition of this book, published in 1935. It was a somewhat abridged edition of Timoshenko's "Strength of Materials" particularly suited to the undergraduate. This second edition carries on the same lines of its predecessor but is brought up-to-date both in improvement of presentation as well as the addition of new material.

The general trend of the treatment shows a sympathetic attitude toward the situation of the student. It does not, however, give concessions in the way of facilitating understanding at the expense of points of importance or of work. The text itself consumes some 330 pages and no space is wasted. Covered in order from the beginning are the subjects tension and compression, shearing stress, combined stresses, torsion, and a discussion of stresses in beams. With reference to the deflection of beams, the methods discussed for determining these deflections include the double integration method, the area-moment method, and the supplementary method of superposition. Statically indeterminate problems in bending are next taken up followed by a discussion on special topics such as the theory behind the bending of steel beams beyond the yield point and also the bending of bars of materials such as cast iron or concrete. The subject of columns is given special attention and a comprehensive description is given of the elements of photoelastic theory.

The work contains a large number of diagrams and there is a sufficiency of illustrative examples giving explicit directions and explanations. Features are completeness and thoroughness. As a text and as a reference book it may be recommended.

R. H. Oppermann.

Statistical Mechanics, by Joseph Edward Mayer and Maria Goeppert Mayer. 495 pages, illustrations, 16 × 24 cms. New York, John Wiley & Sons, Inc., 1940. Price $5.50.

The applications of statistical mechanics are ever widening. The general theorems and methods which make up the science of statistical mechanics are taking their proper place in the treatment of systems for which, because of their great complexity and size, the detailed methods of mechanics would be valueless. For the chemist, one of the most fruitful accomplishments of statistical mechanics has been the accurate calculation of the free energy, entropy, and specific heat of many of the simpler gases from spectroscopic information. Yet, knowledge possessed by many chemists is somewhat limited with regard to theoretical physics. The aim of this book, according to the authors, is to present the subject in a simple manner in order to make it available for just such situations.

Written for graduate students, it necessarily requires thorough undergraduate training in mathematics and scientific subjects. The book starts out by giving a rather simple example of application, that of the perfect monatomic gas, as an illustration of the possibilities of statistical methods. It then summarizes all the theorems and results of mechanics and quantum mechanics. The fundamental concepts are discussed in detail and illustrated with some simple systems. From the theorem of equal probability the derivation of the general laws of thermodynamics is made and the methods are shown by which the thermodynamical properties of a system may be calculated. Subsequently the methods are applied to special systems and the treatment in the book includes the use of some of the more detailed results of quantum-mechanical calculations for the constituent molecules. For instance, the equations for the energy levels of monatomic, diatomic, and polyatomic molecules in terms of their quantum numbers are used in calculating the free energies of gases composed of these molecules. The numerical values of the energy levels are always taken from experimental spectroscopic tabulations.

By means of a variation of the methods used up to this point, there are derived the equations for the conditions of chemical equilibrium, which later are applied to a mixture of isotopes to show that the equilibrium in all chemical reactions, at high temperatures, with the neglect of the effect of the differences in masses, is not altered by the presence of the isotopic differences between some of the atoms of an element. Following this there is treated the general equations for systems composed of dependent particles, the solid crystalline state, the van der Waals Equation, the imperfect gas, and condensation and the critical region. The latter part of the book is devoted to the effect of electric and magnetic forces applied to the systems by means of external electric or magnetic fields, and a discussion of degenerate gases wherein the equations for radiation and for Fermi-Dirac and Bose-Einstein gases at low temperatures are developed. This includes the relation between the properties of the two types of gases and those of electrons in metals and liquid helium.

The book gives a coverage sufficient in every respect for practical use. The treatment is necessarily rigorous within the established boundaries and its arrangement as a logical sequence should make it attractive to those in need of such knowledge.

R. H. OPPERMANN.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Volume 137, Institute of Metals Division, 1940. 487 pages, illustrations, 16 × 23 cms. New York, Institute. Price $5.00.

The one hundred and thirty-seventh volume of the Transactions of the Institute and the fourteenth volume of the Metals Division contains thirty-two papers dealing with metallurgical phenomena of current and permanent interest. Especial attention is directed to the paper "Acceleration of the Rate of Corrosion of High Constant Stresses" by E. H. Dix, Jr. which is the 19th Annual Lecture of the Institute of Metals Division.

The volume is provided with an index covering seven pages.

W. P.

CHAMBERS'S TECHNICAL DICTIONARY, COMPRISING TERMS USED IN PURE AND APPLIED SCIENCE; MEDICINE; THE CHIEF MANUFACTURING INDUSTRIES; ENGINEERING; CONSTRUCTION; THE MECHANIC TRADES, WITH DEFINITIONS BY RECOGNIZED AUTHORITIES, edited by C. F. Tweney and L. E. C. Hughes. 957 pages, 15 × 21 cms. New York, The Macmillan Company, 1940. Price $5.00.

A new dictionary of scientific terms has recently made its appearance from the house of the Macmillan Company. The senior editor is already known for his Technological and Scientific Dictionary which appeared nearly forty years ago. It was an extremely useful work and still has its place on the reference shelf. The present work is more than a second edition, it is a new work and contains much useful data in many branches of science, including a list of trade-names. The editors have had the cooperation of a staff of twenty-nine specialists. The concluding pages are devoted to the chemical elements, the periodic table, igneous rocks, sedimentary rocks, the vegetable and animal kingdom and a bibliography of recent technical works.

It will be very useful.

W. P.

THE AMERICAN ANNUAL OF PHOTOGRAPHY, 1941, edited by Frank R. Fraprie and Franklin I. Jordan. Volume Fifty-Five, 322 pages, illustrations, 19 × 25 cms. Boston, American Photographic Publishing Co., 1940. Price $2.25.

The fifty-fifth volume of this well-known photographic annual has recently come from the press. It contains articles by well-known workers in the several fields of photography and beautiful illustrations by many artists.

The final pages are devoted to "Who's Who in Pictorial Photography" which contains a list of photographers who have had prints accepted by two salons within the current exhibition year. This list contains the names of over 1100 artists from all parts of the world.

The American Annual Formulary giving the latest development and other formulae completes the volume.

W. P.

THE LAYMAN SCIENTIST IN PHILADELPHIA, A DIRECTORY OF AMATEUR SCIENTISTS' ORGANIZATIONS AND RESOURCES IN SCIENCE, 1940, edited by W. Stephen Thomas. 44 pages, illustrations, 15 × 23 cms. The American Philosophical Society, Committee on Education and Participation in Science. Price 15 cents.

This interesting study of Philadelphia's educational facilities reveals the fact that there are 287 active amateur organizations with a membership of some 32,000 persons who have access to 72 different museums, institutes, libraries, observatories and the other science resources. The adult public may avail itself of over 120 courses in 19 fields of science.

The Editor deserves most credit for this compilation but it does indicate that there is some cooperation among the institutions and societies of Philadelphia.

R.

HANDBOOK OF MATHEMATICAL TABLES AND FORMULAS, compiled by Richard Stevens Burington. 275 pages, illustrations, 14 × 21 cms. Sandusky, Handbook Publishers, Inc.

The second edition of this useful reference book has been revised and enlarged. It has been compiled to meet the needs of students and workers in mathematics, engineering, physics and chemistry. It is included as an appendix to the Handbook of Chemistry edited by Norbert Adolph Lange which seems to indicate that the various tables and data are of especial value to the professional chemist.

W. P.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Volume 140, Iron and Steel Division, 1940. 514 pages, illustrations, 16 × 24 cms. New York, Institute. Price $5.00.

The Iron and Steel Division has just issued the 1940 volume of its papers. This is the one hundred and fortieth volume of the Transactions of the Institute. It contains twenty-two technical papers on pig iron and stainless steels. Six papers are devoted to physical metallurgy including the subject of the mechanism of austenite decomposition. Slag control, the subject of the annual Howe Memorial Lecture, was delivered by Dr. Charles H. Herty, Jr. The volume also includes a Round Table on Experimental Methods in the Study of Steelmaking.

Any one interested in steel will find here the latest discussions on the subject.

W. P.

THE EARLY DAYS OF THE POWER STATION INDUSTRY, by R. H. Parsons. 217 pages, plates, 16 × 25 cms. New York, The Macmillan Company, 1940. Price $3.50.

The history of the central station industry in the United States is quite well known, not only from the many books published on the subject but from many other sources. The history of the industry in England is not so well known, at least in America. The title of this book, apparently meant for the Englishman, does not convey the same meaning to the American, for he would take it as the Early Days of the Power Station in America, whereas it really means in England. As such it should have special interest to the American.

There is a similarity, even a parallel, in the development of the industry in both countries in the early days. This book gives an account of electricity supply as it was in the days when every enterprise was largely of a pioneering nature, up to the turn of the century. Much information is given on the introduction of electric lighting in London, the important inventions that have contributed to the furtherance of it, and the establishment of generating stations. There is a description of the Grosvenor Gallery and Deptford Stations, the origination of the corporations that made generation and distribution practicable, and the plans and continuation of the enterprises. Personalities are interwoven in the story—those who played a prominent role as promoters and engineers. In this connection, the narrative of the power station of The Great Western Railway Co. at Paddington is of particular interest.

Early high-tension systems are described as are some of the early London supply companies and municipal power stations each individually. The Battle of the Systems is the title of a part of the book which has, perhaps, the greatest appeal to the American. It relates a conflict of thought and practice in England between those who advocated the small station serving a limited area with direct current, and those who believed in the future use of alternating current for larger areas and higher transmission voltages. Tables give the particulars of the principal London undertakings, the type of current supplied, and the date when they ceased generating.

The rest of the book is devoted to the topics of prime movers in the central station—the gas engine, the reciprocating engine and the introduction of the steam turbine. Somewhat out of line with the rest of the book in limiting treatment to early developments is the brief sketch of legislation affecting the electrical industry, the need for it, its results, and the formation of the interconnected high-voltage grid. Statistical matter on the heat consumption of power stations and the effect of load factor and output on efficiency are given in appendixes.

The book contains a subject index, some twenty-four plates illustrating the various stations and five charts. It is of particular interest to those employed in the central station industry in America.

R. H. OPPERMANN.

ELEMENTARY QUANTITATIVE ANALYSIS, THEORY AND PRACTICE, by Hobart H. Willard and N. Howell Furman. Third Edition, 531 pages, illustrations, tables, 15 × 22 cms. New York, D. Van Nostrand Company, Inc. Price $3.25.

The methods of quantitative analysis are by no means static or fixed. Concerned with the determination of the amounts by weight or by volume of the various substances in a known weight or volume of a compound or a mixture, research is necessary by especially trained scientists for its contribution to the progress of the subject as a whole. With this in mind, a text on elementary quantitative analysis has particular significance.

The book at hand is in its third edition since the year 1933. In line with many texts of this nature, it stresses gravimetric and volumetric methods and cites many references including books, monographs and journal literature. The first part of the book is devoted to preparation for the work of quantitative analysis. It concerns the preliminary laboratory work such as sampling, preliminary examination, a description of the balance and weighing, scientific instruments which deals with accuracy, precision, errors, etc., and fundamental laws and theories. At this point introduction is made to volumetric analysis, laying down the general principles, after which the reactions used are divided and treated separately. These are (1) acidimetry and alkalimetry or neutralization reactions involving only the neutralization of acids and bases, (2) precipitation and complex formation reactions involving only the interchange of ions, (3) oxidation-reduction reactions involving changes in oxidation number or state of oxidation of the reacting substances. In this regard, oxidations with potassium permanganate, potassium bichromate, ceric salts, and processes involving iodine are covered.

Gravimetric analysis is next taken up, followed by electrolytic precipitations and separations, analysis of alloys, and colorimetric analysis. Appendixes contain useful data in the form of tables, lists, and notations supplemental to the coverage generally.

The text contains many review questions and problems which bear evidence of having been carefully formulated. The main feature of the book is simplicity of presentation, derived mainly from its logical progression. In the back is an author and subject index which is indispensable for reference.

R. H. OPPERMANN.

PHENOMENA AT THE TEMPERATURE OF LIQUID HELIUM, by E. F. Burton, H. Grayson Smith and J. O. Wilhelm. 362 pages, illustrations, 16 × 24 cms. New York, Reinhold Publishing Corporation, 1940. Price $6.00.

Ever since the laboratory at Leiden under Kammerlingh-Onnes first liquefied helium in July 1908, low temperature research and exploration has been a fertile field. The findings and presumptions in this new world have been and are not less than astounding. While considerable advance has resulted from this work due mainly to persistency and development of methods there are still theoretical explanations which are as yet in the speculative stage, and the time is here when it is necessary to take stock, reëxamine the entire field and its state of development, to determine and plan the course. It is at this stage that a monograph is most useful.

The present book, one of the American Chemical Society Monograph Series, discusses the many researches that have taken place. Generally, it may be viewed as two parts, the first being a fairly complete introduction to the means of production of low temperatures including the liquefaction of air, nitrogen and oxygen, hydrogen and helium, the measurement of low temperatures, and the physical properties of liquid and solid helium; the second presenting the results of the impact of curious low-temperature phenomena on our modern theories of matter, particularly on the theories of the solid and liquid states. Superconductivity, specific heats at low temperatures, magnetic properties, and temperatures below 1° K. are headings.

While the subjects chosen for discussion are limited to those which are of particular interest at very low temperatures, the authors have wandered freely outside the limited temperature range suggested in the title, to whatever seemed necessary or interesting. This is done in a contributory manner, not conflicting with the general trend.

The work is of the same high standard format as other A.C.S. series monographs containing tabular data, curves and formulæ. Due reference is made throughout to many workers and there is an author and comprehensive subject index. The book is recommended as an authoritative source of information and an invaluable reference to the many whose interests lie in this direction, and particularly to chemists as well as physicists.

R. H. OPPERMANN.

PHOTOGRAPHIC FACTS AND FORMULAS, by E. J. Wall. Revised and largely rewritten by Franklin I. Jordan. 384 pages, illustrations, 16 × 24 cms. Boston, American Photographic Publishing Co., 1940. Price $2.50.

According to the preface of this book, it follows a long line of distinguished predecessors which have been the working companions of a full generation of photographers. The work was first undertaken by H. Snowden Ward and carried on in successive editions culminating in the edition of 1924, the predecessor of this edition. When the tremendous strides of photography since 1924 are taken into account, it is indeed remarkable that so many of the old formulas are still of practical value as is evidenced by the contents of this book.

The book is essentially a work book. Differing from a text, its arrangement and presentation take more of the form of well ordered notes of pertinent material divided into some twenty-five topics. These include optics, exposure, development, printing, copying, color photography, technique generally, and chemical data. As in a note book, no space is wasted, but unlike a note book the material is far more complete with drawings, formulæ, and many tables. It is applicable, therefore, for a wide photographic practice. Also in accord with the nature of the book, the statements contained in it are direct almost to the point of abruptness. This is of great advantage to the photographer of high technical grade. The advantage, however, diminishes in proportion to the technical knowledge and experience of the user. While many parts of the book contain information of value to the beginner, its greatest value is as a ready assistant to the professional.

The 374 pages are just chock full of information. It is conveniently arranged for ready use and the subject index enhances its usefulness. Undoubtedly from this wealth of material can be obtained that which is needed for any occasion within the scope of the subject, whether it be descriptive of new processes or short cuts in present operations.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

The Story of Vitamin B_1, compiled by C. R. Addinall. Revised Edition, 1940. 72 pages, illustrations, 22 × 28 cms. Rahway, Merck & Co. Inc.

A Treatise on Advanced Calculus, by Philip Franklin. 595 pages, 16 × 24 cms. New York, John Wiley & Sons, Inc., 1940. Price $6.00.

The American Annual of Photography, 1941, edited by Frank R. Fraprie and Franklin I. Jordan. Volume Fifty-Five, 322 pages, illustrations, 19 × 25 cms. Boston, American Photographic Publishing Co., 1940. Price $2.25.

Electrical Circuits and Machinery, by Frederick W. Hehre and George T. Harness. Volume I, Direct Currents. 513 pages, illustrations, 16 × 24 cms. New York, John Wiley & Sons, Inc., 1940. Price $4.50.

An Introduction to the Kinetic Theory of Gases, by Sir James Jeans. 311 pages, illustrations, 15 × 23 cms. New York, The Macmillan Company. Price $3.50.

An Introduction to Abstract Algebra, by Cyrus Colton MacDuffee. 303 pages, 16 × 24 cms. New York, John Wiley & Sons, Inc., 1940. Price $4.00.

Principles of Electrical Engineering, by William H. Timbie and Vannevar Bush. Third Edition completely rewritten, 540 pages, illustrations, 15 × 23 cms. New York, John Wiley & Sons, Inc., 1940. Price $4.50.

Transactions of the American Institute of Mining and Metallurgical Engineers. Volume 140, Iron and Steel Division, 1940. 514 pages, illustrations, 16 × 24 cms. New York, Institute. Price $5.00.

Canada, Department of Mines and Resources, Mines and Geology Branch, Bureau of Mines. No. 803, Talc, Steatite, and Soapstone; Pyrophyllite, by Hugh S. Spence. 146 pages, plates, illustrations. Department of Trade and Commerce, Dominion Bureau of Statistics, Mining, Metallurgical and Chemical Branch. Coal Statistics for Canada, for the calendar year 1938. 114 pages, illustrations. Manufactures of the Non-Ferrous Metals in Canada, 1937 and 1938. 101 pages. 3 pamphlets, 17 × 25 cms. Ottawa, King's Printer. Price 50 cents each.

Bell Telephone System, Monographs: B-1238, Co-ordination of Power and Communication Circuits for Low-Frequency Induction, by J. O'R. Coleman and H. M. Trueblood. 19 pages, illustrations. B-1241, Analysis of the Ionosphere, by Karl K. Darrow. 34 pages, illustrations. B-1245, High-Gain Amplifier for 150 Megacycles, by G. Rodwin and L. M. Klenk. 13 pages, illustrations. B-1246, Sound Measurement Objectives and Sound Level Meter Performance, by J. M. Barstow. 42 pages, illustrations. B-1247, Helium the Superfluid, by Karl K. Darrow. 23 pages, illustrations. B-1248, Rectilinear Electron Flow in Beams, by J. R. Pierce. 17 pages, illustrations. 6 pamphlets, 15 × 23 cms. New York, Bell Laboratories, 1940.

CURRENT TOPICS.

Chicago Builds a Subway.—C. H. Vivian (*Compressed Air Magazine*, Vol. 45, No. 8.) Some time in 1941, Chicagoans will take their first subway rides in their home city. Some of the passengers will be great grand-children of the men who first proposed an underground railway system for Chicago in the 1880's, for it has taken more than half a century to make the transition from debate to construction. During the interim, numerous schemes have been advanced and rejected. Thus, America's second largest city will, belatedly, become one of the group of municipalities that do a portion of their traveling beneath the streets. Boston built the first subway in this country in 1898, thirty-five years after subterranean transportation of persons was introduced in London. New York opened its first subway in 1904, and now, with 133 route-miles, leads all other world cities in mileage. Philadelphia's first subway was constructed in 1908. Chicago's first subway is visioned as the nucleus of a future comprehensive network, and from that viewpoint the lines now being built are considered primarily as the hub of the ultimate system, together with short stretches of the branches that will eventually radiate from this central area to various parts of the city. They will, nevertheless, give immediate relief to existing, congested transit facilities in the downtown "Loop" section, where trains on the forty-three year old elevated railroad system are so numerous during rush hours as to slow them down to an almost intolerably slow speed. The initial system will consist of 7.7 route-miles of double tube subway. It is divided into two lines, known as the State Street and Dearborn Street subways, these being the names of the two streets where most of the passengers will board or leave the trains in the downtown business area. It is expected that the subway will reduce the maximum hourly movement of elevated trains in the "Loop" from 68 to 38 trains and that this will cut seven minutes from the time required to make a circuit of the "Loop" in rush periods. It is figured that 100,000,000 passengers will be carried annually by this initial subway system.

R. H. O.

High Speed Turbines Improve Effeciencies.—(*Power Plant Engineering*, Vol. 44, No. 8.) Contrary to the preconceived ideas of many engineers, operating experience with both land and marine units seems to indicate definitely that the new higher speed turbines are more reliable and more economical than the older slower speed machines, according to GLENN B. WARREN, turbine design engineer of the General Electric Company. Speaking at the semiannual meeting of the American Society of Mechanical Engineers at Milwaukee, Mr. Warren pointed out that the trend to higher speeds has permitted a better use of materials in turbines and has lowered investment and operating costs under what they would have been had speeds not been increased. The trend toward higher turbine speeds has been dictated by a number of factors. First is the question of efficiency. In the second place, however, and perhaps of even greater importance, is the fact that it becomes very much easier to build reliable turbines for high pressures and temperatures if the shells and rotors and interstage diaphrams are kept as small as possible. This can be done in higher speed turbines. Mr. Warren pointed out that although the largest possible unit at any given speed has steadily increased, and the large units have been effectively utilized in reducing operating and fixed costs on the large utility systems, the average size of unit sold in U. S. (units above 10,000 kw. considered) has increased but slowly. Increases in maximum pressure and temperature have been followed by a steady rise in the average pressure and temperature for which machines have been sold, thus certifying to the fact that the pioneering done by a few power plant owners has been followed by an advance in the entire industry.

R. H. O.

New Construction Principles for Homes.—"Plank-and-Beam and Roof System for Residential Construction," a 16-page booklet describing the advantages of this system and its adaptation to residential construction has recently been published by the National Lumber Manufacturers Association. This method of design long used in factory structures but relatively new in residential building, has been a subject of study by the Technical Department of the N. L. M. A. since 1937. During this period several homes incorporating the system, including one at the New York World's Fair, were built as tests. One demonstration house at Fairway Hills, Maryland, showed that the plank floor in comparison with a joisted floor was 24.8 per cent. more efficient from the standpoint of insulation and required 26.3 per cent. less labor time; 13.6 per cent. less labor time per thousand feet of lumber; 14.7 per cent. less lumber per square foot of floor area, and 22.6 per cent. less expensive per square foot of floor area. A more complete study, including data from all the "test" houses, revealed that the use of plank-and-beam floor and roof construction: (1) reduces the number of pieces a carpenter must handle, saw, align, and nail; (2) reduces the number of points at which the floor must be nailed to the supporting beams; (3) reduces the lumber requirements for the beams; (4) eliminates all bridging; (5) permits increased use of lower grades of lumber; (6) provides more insulation without additional cost; (7) reduces waste of material by permitting use of multiples of standard lumber lengths; (8) reduces the handling of varying lengths and sizes of lumber; (9) simplifies construction details; (10) requires shorter wall studs; (11) reduces the exterior wall height and overall height for the same ceiling heights, giving more usable cubage in a house of the same size or the same usable cubage in a house of smaller size; (12) eliminates the layer of finish ceiling material such as lath and plaster by letting the underside of the plank serve as finished ceiling; (13) provides a solid backing in place of spaced, narrow faced nailing members for the application of any ceiling materials, if they are desired, by leaving the beams exposed; (14) provides a thicker nailing base for the finish floor, and (15) permits speedy, dry built construction.

R. H. O.

New "Magic Carpet."—(*News Edition American Chemical Society*, Vol. 18, No. 16.) Greater safety for patrons of modern motion picture theaters is provided by a new "magic carpet" which glows in the dark, according to H. E. Millson of the Calco Chemical Division, American Cyanamid Co., Bound Brook, N. J. The new carpet is dyed with special dyes which appear quite ordinary in daylight but glow softly with various colors in the "black light" of invisible ultra-violet rays. The absolute darkness necessary to bring out the full beauty of modern motion pictures in color has increased the chance of accident to people entering theaters from brightly lighted foyers, Mr. Millson said, and to overcome this, carpets can be colored with fluorescent dyes to light the way in total darkness. Instead of the usual shaded lights along the aisles of theaters (which interfere with the fidelity of colored pictures and generally illuminate only the area near the light), small electric tubes shed ultra-violet rays on the carpet. This same effect is utilized in modern fluorescent tube lamps which yield light with a minimum of heat. The exact nature of fluorescence is not completely understood, but apparently when ultra-violet rays are absorbed by fluorescent materials, these substances radiate soft visible light. This property, possessed by quinine sulfate, certain dyes, minerals and numerous other substances, has been utilized for many purposes including identification of minerals, examination of questioned documents, fluoroscopic screens which make X-rays visible, and the viewing screens of television. The present patented application of fluorescent dyes as guides in the dark is expected to have important uses in other fields.

R. H. O.

Salts of the Precious Metals.—The compounds of the platinum metals and of gold are finding increasing use in the arts and science, such as reactions involving catalysis, preparation of electroplating baths, photographic toning, ceramic coloring, etc. The widespread interest thus created has led Baker & Co., Inc., of Newark, New Jersey, to prepare a booklet on the subject useful as a reference work. In it, in tabular form, there is given the descriptive properties of the compounds of platinum, palladium, rhodium, iridium, ruthenium, osmium, and gold. The data includes tables on solubility which are of exceptional value.

R. H. O.

Screw Threads.—A. M. SMITH in *Iron Age*, Volume 146, No. 8, describes an investigation to find out what effect the method of manufacture of the thread has upon the ultimate tensile strength, the fatigue limit, and the ratio between the two. Three manufacturing methods were selected: (*a*) cut threading; (*b*) roll threading on single extruded wire; and (*c*) roll threading on double extruded wire. The fatigue tests were made on special machines of the Sondericker type in which the specimens are loaded like a simple beam which is then rotated rapidly. Thus the "fibers" of steel in one rotation are stressed in tension and then in compression. All specimens were made with 3/8–24 American Standard threads and were 4 in. in length. The tensile and impact-tension specimens were all made with full threads the full length of the specimens. The fatigue specimens were made with 1 in. of full threads in the middle of the specimen. With regard to ultimate tensile strength the tests show that cut threads are as strong in tension as the material used, single extruding and rolling threads increase the tensile strength about 12 per cent. over that of the original material, double extruding and rolling threads increase the tensile strength about 28.5 per cent. over that of the original material. With regard to the effect on the endurance limit of the method of manufacture, the tests indicate that cut threaded specimens have an endurance limit about 30 per cent. of the ultimate strength of the threads, and also the original material, single extruded and roll threaded specimens have an endurance limit about 33 per cent. of the ultimate strength of the thread, and about 37 per cent. of the original material, double extruded and roll threaded specimens have an endurance limit about 33 per cent. of the ultimate strength of the thread and about 42.6 per cent. of the strength of the original material. If the material of the same ultimate strength were used for all three specimens, the cut thread specimens would be weakest in tension and endurance, the single extruded and roll threaded specimens would be next, and the double extruded and roll threaded specimens would be strongest.

R. H. O.

The Oxidation of Aromatic Hydrocarbons.—C. R. DOWNS of Weiss and Downs, Inc., stated in a paper before the recent Detroit meeting of the American Chemical Society, that toluene, naphthalene, and anthracene were for many years oxidized by chemical methods in the liquid phase respectively to benzoic acid, phthalic anhydride, and anthraquinone. Later it was found that they could be oxidized to these same products more cheaply by air at elevated temperatures in the vapor phase in contact with various solid catalysts. All these products, however, are now made from one raw material, namely, naphthalene, rather than from what offhand would appear to be their most logical sources. This result has been dictated by economic reasons which the chemical engineer must always recognize as being of more importance than the chemical reactions themselves. In order to emphasize this point, it seems proper to trace the histories of these products and point out their economic effects. All benzoic acid and anthraquinone and its derivatives now made in the United States are produced from phthalic anhydride, which in turn is made by the vapor phase catalytic oxidation of naphthalene. In addition to these uses phthalic anhydride is of great importance in its own right especially in the synthesis of synthetic resins. It is estimated that the present production capacity of phthalic anhydride equipment in the United States is about 75,000,000 pounds per year. There is no potential shortage of domestic naphthalene for producing phthalic anhydride in much larger quantities than is indicated for future consumption. If the catalytic oxidation of naphthalene to phthalic anhydride were not known, phthalic anhydride could not occupy its present outstanding importance as an intermediate. By the old process using sulfuric acid to oxidize naphthalene, the present installed capacity would require an estimated annual consumption of 750,000 tons of 100 per cent. sulfuric acid. The cost of contact sulfuric acid plant for this is estimated at close to $8,000,000 and the acid cost alone would probably amount to 25 per cent. of the present sales price of phthalic anhydride.

R. H. O.

The Destructive Distillation of Maple Wood.—DONALD F. OTHMER and W. FRED SCHURIG of the Polytechnic Institute of Brooklyn presented a paper before the Detroit meeting of the American Chemical Society which stated that few reports are available describing experiments showing the effect of different variables on the carbonization of hard wood; and the last ones, with incomplete data, were made some 20 to 25 years ago. There are numerous variables involved in the unit process of destructive distillation as applied to hard woods; and some of these have been studied in their relation to the carbonization of maple cord wood sticks about 17 inches long. A series of runs were made to study the effect of time and temperature (taken at a half-dozen different points throughout the heating assembly), the moisture content of the wood, the age of the wood after cutting, the season of the year when the wood was cut, etc. The retort used was a vertical cylinder with the wood standing on ends. The products obtained were determined: the charcoal as the residue; the acetic, methanol, tar amount and composition of the wood gas at different times during the runs. Much larger amounts of acetic acid and methanol and lower amounts of charcoal were obtained in this retort and with the method of firing used than are obtained in industrial practice indicating that the volatile products may be increased at the expense of the charcoal in a properly designed plant and properly conducted operation. Runs were so made (including one on cotton cellulose) that some conclusions as to the nature of the decomposition and the parts of the wood the various products came from could be drawn.

R. H. O.

U. S. Helium Plant Produces 100 Million Cubic Feet.—(*Gas*, Vol. XVI, No. 9.) The world's only operating helium plant maintained by the United States Government near Amarillo, Texas, has completed producing 100 million cu. ft. of helium, the Secretary of Interior has been advised by the Bureau of Mines. The plant is prepared to meet any demands probable for helium from the United States Army or Navy in the national defense program. Helium, a non-explosive lighter-than-air gas, is of particular military value for airships. Action by the Secretary of Interior in a peace time controversy over a year ago precluded foreign accumulation over-seas of any United States helium of military significance. Figures just compiled by the Bureau of Mines show that the government plant has produced 100,102,000 cu. ft. of helium during its operating life of a little more than 11 years. This production is less than 50 per cent. of the potential output for an equal period if the plant were run at its rated capacity. Altogether, the government has produced nearly 150 million cu. ft. of helium, as 48 million cu. ft. were produced at Fort Worth, Texas, before the Amarillo plant was in operation.

R. H. O.

The Cotton Cement Shingle.—GENE HOLCOMB (*Manufacturers Record*, Vol. 109, No. 9). Invented by J. Harris Hardy with the assistance of a number of other workers, the cotton cement shingle will evidently free roof designing from numerous construction restrictions. Composed of an unevenly proportioned cement mix embedded with a cotton fabric aggregate and temporarily covered with an impervious wax paper, the material succeeds in two important departures from the usual in roofing materials. First, it is manufactured on the building site and laid wet, ten or fifteen minutes after making; second, it is cured on the roof in the position in which it will function. The result, as revealed by laboratory test and commercial application is a strength and working flexibility heretofore unclaimed for cement or other types of roofing materials. Wet shingles, like any bonded wet cement mix, lend themselves advantageously to handling. Flexible, they eliminate the necessity for metal flashing and ridge roll, and can be laid over either new, smooth sheathing or old, uneven cedar shingles. The process of manufacturing is relatively simple. The cement mix, consisting of one part cement, two parts of sand, and one part of water, is prepared in a small orthodox mixer. After mixing, the mortar is placed in a form lined with impervious wax paper. The form may be designed to produce a shingle, slate or thatch effect. From the molding table the mix is placed on a vibrating table that has been adjusted at the rate of 5000 impulses a minute. Here the cement is made compact and deprived of voids or air bubbles. Here, also, the cotton fabric (closely resembling a rectangular strip of citrus bagging) is embedded in the mortar under hand pressure and smoothly covered over. When the form leaves the vibrating table a fifteen pound felt base is placed over the mortar and edges folded over to seal the mixture. The material is then placed on an ordinary metal pallette and hoisted to the house top, where it is applied immediately, felt base down, impervious paper up.

R. H. O.

INDEX TO VOLUME 230.

July to December 1940.

Airfoils in non-uniform motion. Operational methods in the (Sears), 95
Astronomical hypothesis to explain Permian glaciation (Ives), 45

Bactericidal irradiation of air (Opatowski), 643
Baekeland, Leo H.: The career of a research chemist, 159
Book Reviews:
  American Annual of photography, 1941, 790
  American Institute of Mining and Metallurgical Engineers, Transactions:
    Metals division, 1940, 789
    Iron and sheet division, 1940, 791
  Bachelier, L.: Les nouvelles méthodes du calcul des probabilités, 137
  Baker, R. H.: An introduction to astronomy, 521
  Burington, R. S.: Handbook of mathematical tables, 791
  Burton, E. F., H. G. Smith & J. O. Wilhelm: Phenomena at the temperature of liquid helium, 793
  Casimir, H. B. G.: Magnetism and very low temperatures, 527
  Chalmers, B.: Physical examination of metals, vol. 1, 136
  Chambers's technical dictionary, 790
  Chemical Engineering Catalog, 1940, 674
  Dorsey, N. E.: Properties of ordinary water-substance, 271
  Duff, A. W. & S. J. Plimpton: Elements of electro-magnetic theory, 412
  Dunn, C. E.: Natural color processes, 526
  Eddington, A.: The philosophy of physical science, 135
  Egloff, G.: Physical constants of hydrocarbons, volume 2, 271
  Ellis, C.: Printing inks, 525
  Harvey, E. N.: Living light, 273
  Karman, T. v. & M. A. Biot: Mathematical methods in engineering, 139
  Kilby, C. M.: Laboratory manual of physics, 411
  Laporte, M.: Décharge électrique dans les gaz, 135
  Lawrence, R. R.: Principles of alternating-current machinery, 523
  Lindsay, R. B.: General physics, 140
  Massachusetts Institute of Technology: Principles of electrical engineering series. Electric circuits, 673
  Mayer, J. E. & M. G.: Statistical mechanics, 788
  Minnaert, M.: Light and colour, 522
  National Advisory Committee for Aeronautics: No. 681, 136; No. 682, 137; No. 686, 137
  National Research Council: Twelfth Report of the Committee on Catalysis, 527
  Parsons, R. H.: The early days of the power industry, 791
  Powell, R. W.: Mechanics of liquids, 525
  Quarles, G. G.: Elementary photography, 272
  Rice, O. K.: Electronic structure and chemical binding, 673
  Sachanen, A. N.: Conversion of petroleum, 524

Sedgwick, W. T. & H. W. Tyler: Short history of science, 138
Seventh Summer Conference on Spectroscopy, Cambridge, 1939, Proceedings, 521
Solomon, A. K.: Why smash atoms, 522
Svedberg, The & K. O. Pedersen: The ultracentrifuge, 141
Taylor, F. S.: Science front, 1939, 272
Thomas, W. S.: The layman scientist in Philadelphia, 790
Timoshenko, S. & G. H. MacCullough: Elements of strength of materials, 788
Wall, E. J.: Photographic facts and formulas, 793
White, H. E.: Classical and modern physics, 411
Willard, H. H. & N. H. Furman: Elementary quantitative analysis, 792
Wilson, A. H.: Semi-conductors and metals, 138
Brown, G. S. & H. L. Hazen: The cinema integraph, 19, 183

Carl, Leroy R.: The breaking theory of detonation, 75, 207, 355
Chemist, research. The career of a (Baekeland), 159
Cinema integraph (Hazen & Brown), 19, 183
Clarke, E. T. & S. A. Korff: Report of cosmic ray observations made on the U. S. Antarctic Expedition in coöperation with the Bartol Research Foundation, 567
Colwell, R. C., A. W. Friend & L. H. Gibson: The velocity of sound, 749
Compton, Arthur H.: What we have learned from scattered X-rays, 149
Compton, Lewis: Naval policies and development since the world war, 677
Conductors, hollow rectangular. Inductance of (Higgins), 375
Cosmic ray observations made on the U. S. Antarctic Expedition in coöperation with the Bartol Research Foundation. Report of (Korff & Clarke), 567
Crabtree, J. I., G. T. Eaton & L. E. Muehler: The elimination of hypo from photographic images, 701
Current Topics: 18, 112, 143, 158, 162, 182, 206, 228, 248, 276, 394, 470, 482, 500, 506, 566, 582, 618, 642, 646, 654, 676, 726, 764, 772, 796

Detonation. The breaking theory of (Carl), 75, 207, 355

Eaton, G. T., J. I. Crabtree & L. E. Muehler: The elimination of hypo from photographic images, 701
Ehrenhaft, Felix: Physical and astronomical information concerning particles of the order of magnitude of the wave-length of light, 381
Engineering world. Man in an (Jackson), 1
Explosives. The breaking theory of detonation (Carl), 75, 207, 355

Finch, James K.: Man's battle against fire, 685
Fire. Man's battle against (Finch), 685
Franklin Institute.
  Bartol Research Foundation:
    Communication no. 102: Report of cosmic ray observations made on the U. S. Antarctic Expedition in coöperation with the Bartol Research Foundation (Korff & Clarke), 567
    Notes: 122, 509, 659, 776
    Report on the work 1939–40, 281
  Biochemical Research Foundation:
    Notes: 125, 263, 402, 514, 664, 781
    Progress, 727
  Library Notes: 119, 261, 401, 507, 655, 774
  Medal day meeting, 249

Monthly meeting: October 16, 1940, 655; November 20, 1940, 773
Science and the Arts Committee: Abstracts of Proceedings: June 12, 1940, 119; November 13, 1940, 773
Friend, A. W., R. C. Colwell & L. H. Gibson: The velocity of sound, 749
Fry, Lawford H.: The steam locomotive: Its development and present position in railroad transportation, 529

Gases. Theory of perfect (Malina), 433
Gemant, Andrew & F. A. Glassow: Compressed magnesia as electrical insulator, 471
Gibson, L. H., R. C. Colwell & A. W. Friend: The velocity of sound, 749
Glaciation, Permian, an astronomical hypothesis to explain (Ives), 45
Glassow, F. A. & Andrew Gemant: Compressed magnesia as electrical insulator, 471
Graham, C. L. & S. E. Sheppard: Extragranular factors in photographic sensitivity, 619

Hazen, H. L. & G. S. Brown: The cinema integraph, 19, 183
Heaviside's expansion theorem. A matrix generalization of (Pipes), 483
Higgins, Thomas James: Inductance of hollow rectangular conductors, 375
Hypo, the elimination of, from photographic images (Crabtree, Eaton & Muehler), 701

Ives, Ronald L.: An astronomical hypothesis to explain Permian glaciation, 45
——The sequence illusion, 755

Jackson, Dugald C.: Man in an engineering world, 1

Korff, S. A. & E. T. Clarke: Report of cosmic ray observations made on the U. S. Antarctic Expedition in coöperation with the Bartol Research Foundation, 567

Lawton, C. S.: A novelty in marine surveying, 455
Lessells, John M. & C. W. MacGregor: Combined stress experiments on a nickel-chrome-molybdenum steel, 163
Light, wave-length of. Physical and astronomical information concerning particles of the order of magnitude of the (Ehrenhaft), 381
Locomotive, the steam: Its development and present position in railroad transportation (Fry), 529

MacGregor, C. W. & John M. Lessells: Combined stress experiments on a nickel-chrome-molybdenum steel, 163
Magnesia, compressed, as electric insulator (Gemant & Glassow), 471
Malina, Frank J.: Characteristics of the rocket motor unit based on the theory of perfect gases, 433
Man in an engineering world (Jackson), 1
Marine surveying. A novelty in (Lawton), 455
McDonald, Ellice: Progress of the Biochemical Research Foundation of The Franklin Institute, 727
McFarland, Earl: Trend in weapon types and design, 413
Meek, J. M.: A theoretical determination of breakdown voltage for sphere-gaps, 229
Moon, Parry: Proposed standard solar-radiation curves for engineering use, 583
Muehler, L. E., J. I. Crabtree and G. T. Eaton: The elimination of hypo from photographic images, 701

National Bureau of Standards: Notes, 113, 243, 395, 501, 647, 765

Naval policies and development since the world war (Compton), 677

Opatowski, I.: Bactericidal irradiation of air, 643

Photographic sensitivity. Extragranular factors in (Sheppard & Graham), 619
Pipes, Louis A.: A matrix generalization of Heaviside's expansion theorem, 483
Publications Received: 142, 274, 528, 675, 794

Rocket motor unit. Characteristics of the (Malina), 433

Sears, William R.: Operational methods in the theory of airfoils in nonuniform motion, 95
Sequence illusion (Ives), 755
Sheppard, S. E. & C. L. Graham: Extragranular factors in photographic sensitivity, 619
Solar-radiation curves, proposed standard for engineering use (Moon), 583
Sound. The velocity of (Colwell, Friend & Gibson), 749
Sphere-gaps. A theoretical determination of breakdown voltage for (Meek), 229
Steam locomotive: Its development and present position in railroad transportation (Fry), 529
Steel, nickel-chrome-molybdenum. Combined stress experiments on a (Lessells & MacGregor), 163
Swann, W. F. G.: Report on the work of the Bartol Research Foundation, 1939–40, 281

Voltage, breakdown for sphere-gaps. A theoretical determination of (Meek), 229

Weapon types and design. Trend in (McFarland), 413
Wells, William Firth: Bactericidal irradiation of air, 645

X-rays, scattered. What we have learned from (Compton), 149